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COMPREHENSIVE STUDY OF WATER AND RELATED LAND RESOURCES. PUGET --ETC(U)
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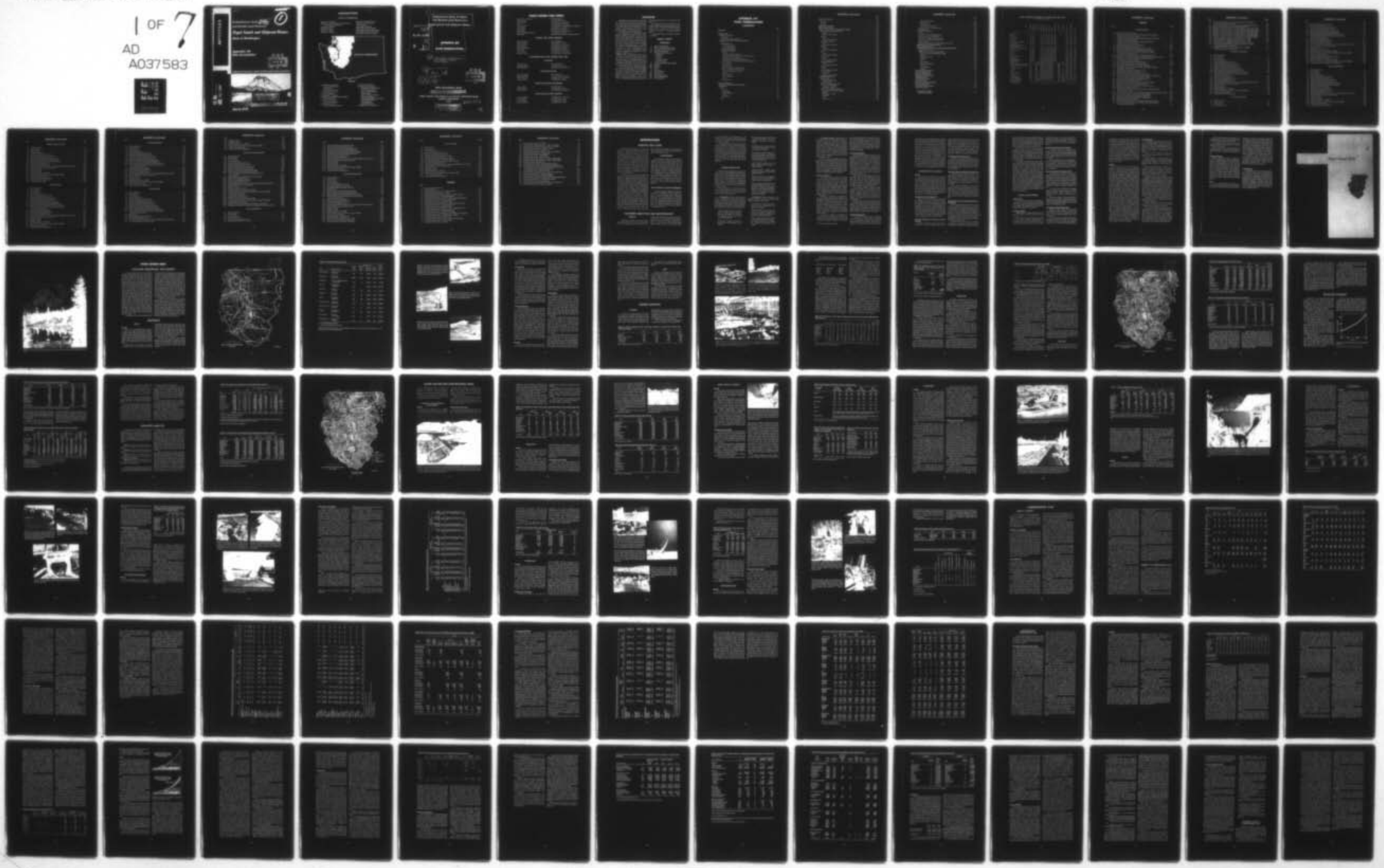

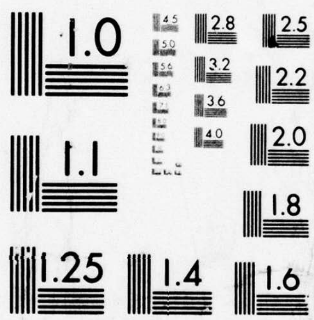

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Comprehensive Study of Water

and Related Land Resources

Puget Sound and Adjacent Waters

State of Washington

Appendix XV
Plan Formulation

Puget Sound Task Force—Pacific Northwest River Basins Commission

March 1970

PARTICIPATION

STATE OF WASHINGTON

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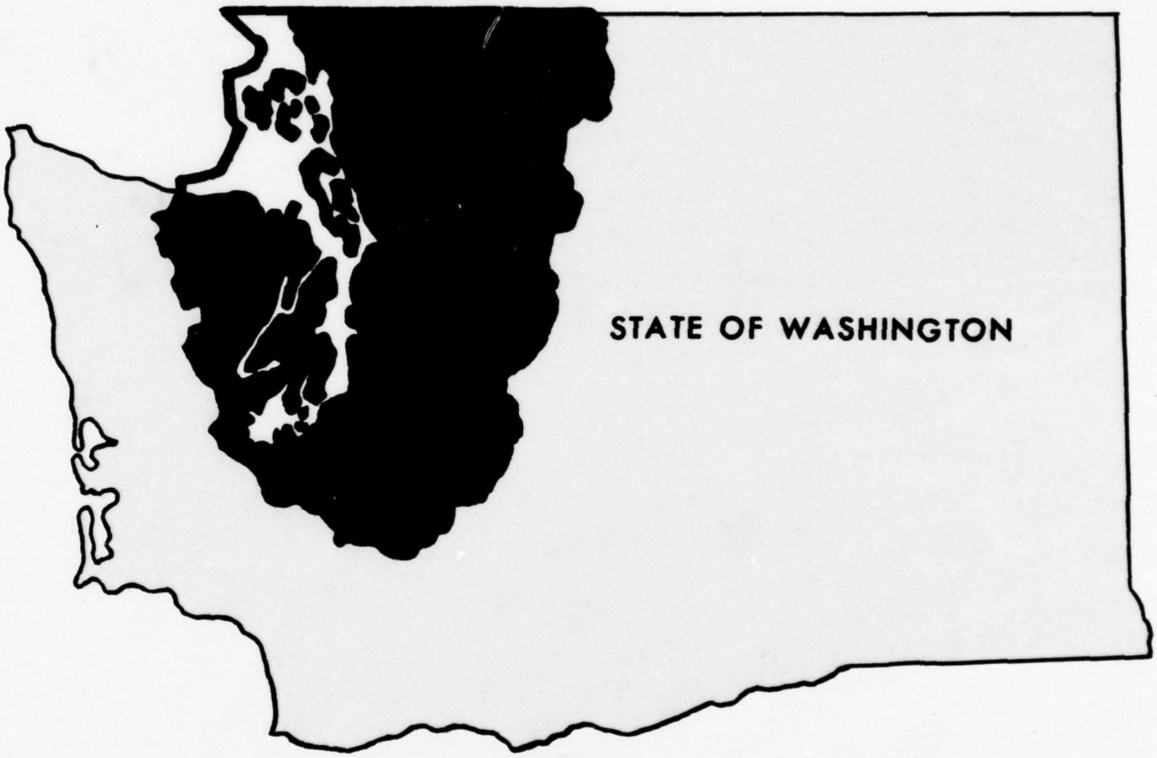
Department of Commerce & Economic Development
    Office of Nuclear Development
Department of Fisheries
Department of Game
Department of Health
Department of Highways
Department of Natural Resources
Department of Water Resources
Canal Commission
Oceanographic Commission
Parks and Recreation Commission
Planning and Community Affairs Agency
Soil and Water Conservation Committee
Water Pollution Control Commission



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U.S. Department of Agriculture
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    Fish and Wildlife Service
    Geological Survey
    National Park Service
U.S. Department of Transportation

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Comprensive Study of Water and Related Land Resources.

Puget Sound and Adjacent Waters.

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APPENDIX XV.

PLAN FORMULATION

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Lewis F. Kehne, L. B. Day
Francis L. Nelson

11 Mar 70

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Plan Formulation Team

PUGET SOUND TASK FORCE of the PACIFIC NORTHWEST RIVER
BASINS COMMISSION
1970

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FOREWORD

APPENDIX XV, Plan Formulation, summarizes the water and related land resource needs of the Puget Sound Area and contains a detailed discussion of a comprehensive plan and alternatives for future preservation, enhancement and development of the resources to meet projected needs. It is one of the technical appendices to the Summary Report.

The Summary Report is supplemented by 15 appendices. Appendix I contains a Digest of Public Hearings. Appendices II through IV contain environmental studies. Appendices V through XIV each contain an inventory of present status, present and future needs, and the means to satisfy the needs, based upon a single use or control of water. Appendix XV contains comprehensive plans for the Puget Sound Area and its individual basins and describes the development of these multiple-purpose plans including the trade-offs of single-purpose solutions contained in Appendices V through XIV, to achieve multiple planning objectives.

The purpose of this appendix is to focus on the accumulation, analysis and presentation of comparative physical and economic data leading to the single-purpose plans for the Puget Sound Area and through use of multiple planning objectives develop a comprehensive plan which is in the overall best interests of the Area, the State and the Nation.

River-basin planning in the Pacific Northwest was started under the guidance of the Columbia Basin Inter-Agency Committee (CBIAC) and completed under the aegis of the Pacific Northwest River Basins Commission. A Task Force for Puget Sound and Adjacent Waters was established in 1964 by the CBIAC for the purpose of making a water resource study of the Puget Sound based upon guidelines set forth in Senate Document 97, 87th Congress, Second Session.

The Puget Sound Task Force consists of ten members, each representing a major State or Federal agency. All State and Federal agencies having some authority over, or interest in, the use of water resources are included in the organized planning effort.

The published report is contained in the following volumes.

SUMMARY REPORT

APPENDICES

I. Digest of Public Hearings
II. Political and Legislative Environment
III. Hydrology and Natural Environment
IV. Economic Environment
V. Water-Related Land Resources
   a. Agriculture
   b. Forests
   c. Minerals
   d. Intensive Land Use
   e. Future Land Use
VI. Municipal and Industrial Water Supply
VII. Irrigation
VIII. Navigation
IX. Power
X. Recreation
XI. Fish and Wildlife
XII. Flood Control
XIII. Water Quality Control
XIV. Watershed Management
XV. Plan Formulation

APPENDIX XV
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INTRODUCTION

PURPOSE AND SCOPE

This Appendix summarizes water and related land resource needs of the Puget Sound Area and presents a comprehensive plan of projects and programs to meet these needs. Future use of water and related land resources in the eleven major river basins comprising the Area are planned to satisfy environmental as well as economic objectives. Non-structural as well as structural means of satisfying projected needs are included in the Plan. Action programs requiring continuous coordination between State, local, Federal and private agencies, are proposed. Legislation, financing and the need for follow-up fact-finding are discussed in the Summary Report with appropriate recommendations made to insure orderly development.

An inventory of the water and related land resources of the Puget Sound Area was made. The physical, economic, political and legislative environments, were examined in depth. Future water and related land resource needs were projected for the years 1980, 2000 and 2020 for the Area on the basis of economic and resource studies. Single-purpose means to satisfy individual water and related land needs given in the separate technical appendices provided a basis for developing a comprehensive water resource plan and alternatives that would best serve all purposes. Economic analyses, including benefit-cost evaluations, were made for urgently needed projects required by 1980. Costs were estimated for projects and programs required by the years 2000 and 2020. Although the Comprehensive Water and Related Land Resource Study of Puget Sound and Adjacent Waters did not deal directly with urban related social problems and land use planning in detail, most of the studies dealt with needs which directly or indirectly affect urban centers. The broad land use planning undertaken serves as a basis for further detailed land use studies, including management of Puget Sound estuaries.

ARRANGEMENT

This Appendix first presents the methodology employed in the plan formulation process and describes the Study Area and its resources. Water and related land needs of the Puget Sound Area, the opportunities considered and the means for satisfying these needs are discussed in the same order as in Senate Document 97, 87th Congress, 2nd Session. The Comprehensive Plan for the Puget Sound Area, its accomplishments, alternative elements and the cost of implementing this Plan are contained in the presentation. A detailed discussion of each of the eleven major river basins studied follows an examination of the effects of the Plan on the Area and an evaluation of impacts from alternative economic projections.

RELATIONSHIP TO OTHER APPENDICES

The Plan Formulation Appendix represents the focal point of accumulation, analysis, and presentation of comparative physical and economic data leading to the Comprehensive Plan for the Puget Sound Area. The technical appendices of the summary report provided the base data used in formulation of the Comprehensive Plan. These appendices present the detailed investigations of all facets of water and related land resource planning considered for the Puget Sound Area.

PLANNING OBJECTIVES AND METHODOLOGY

GENERAL

Comprehensive planning of the Puget Sound Area comprised the analysis of water and related land resources and opportunities and the formulation of a comprehensive plan for the most effective utilization of these resources for the well being of the people. In planning for the Area, thorough consideration was given to a wide range of objectives representing different public interests. These objectives ranged

from the preservation and enhancement of the quality of the environment to efficient development of resources to meet the Puget Sound Area's projected economic growth.

The major elements involved in planning were: (1) the assessment of water and related land resources and present uses; (2) the estimating of needs based on the projection of the economy to the years 1980, 2000 and 2020, and the opportunities to meet these needs; (3) the identification of objectives for management or development of resources and the extent that objectives could be met from existing opportunities; (4) the development of a plan which best serves to satisfy the needs from local, State and national viewpoints.

PLANNING OBJECTIVES

Planning for the management, use, and development of our water and related land resources requires consideration of basic national, regional, and local goals, as well as more specific Federal and State objectives for water and related land resource development and use. Also involved are specific water resource policies at various levels of government which reflect the overall objectives and the legislative framework of water law as it is today and as it may evolve in the future.

Senate Document No. 97, 87th Congress, 2nd Session provides objectives and guidance for planning the use and development of water and related land resources. These broad objectives are:

"**A. Development.**—National economic development, and development of each region within the country, is essential to the maintenance of national strength and the achievement of satisfactory levels of living. Water and related land resources development and management are essential to economic development and growth, through concurrent provision for—

> Adequate supplies of surface and ground waters of suitable quality for domestic, municipal, agricultural, and industrial uses—including grazing, forestry, and mineral development uses.
>
> Water quality facilities and controls to assure water of suitable quality for all purposes.
>
> Water navigation facilities which provide a needed transportation service with advantage to the Nation's transportation system.
>
> Hydroelectric power where its provision can contribute advantageously to a needed increase in power supply.
>
> Flood control or prevention measures to protect people, property, and productive lands from flood losses where such measures are justified and are the best means of avoiding flood damage.
>
> Land stabilization measures where feasible to protect land and beaches for beneficial purposes.
>
> Drainage measures, including salinity control where best use of land would be justifiably obtained.
>
> Watershed protection and management measures where they will conserve and enhance resource use opportunities.
>
> Outdoor recreational and fish and wildlife opportunities where these can be provided or enhanced by development works. Any other means by which development of water and related land resources can contribute to economic growth and development.

"**B. Preservation.**—Proper stewardship in the long-term interest of the Nation's natural bounty requires in particular instances that—

> There be protection and rehabilitation of resources to insure availability for their best use when needed.
>
> Open space, green space, and wild areas of rivers, lakes, beaches, mountains, and related land areas be maintained and used for recreational purposes; and
>
> Areas of unique natural beauty, historical and scientific interest be preserved and managed primarily for the inspiration, enjoyment and education of the people.

"**C. Well-being of people**.—Well-being of all of the people shall be the overriding determinant in considering the best use of water and related land resources. Hardship and basic needs of particular groups within the general public shall be of concern, but care shall be taken to avoid resource use and development for the benefit of a few or the disadvantage of many. In particular, policy requirements and guides established by the Congress and aimed at assuring that the use of natural resources, including water resources, safeguard the interest of all of our people shall be observed."

Pursuant to the basic objectives cited previously, the Comprehensive Water Resource Study of Puget Sound and Adjacent Waters considered the broad objectives of Economic Efficiency and Environmental Quality and Regional Development. These objectives are broad in scope and general in definition, yet they are specific enough to provide the basic principles and guidelines for the formulation of plans of water and related land resource development.

Economic Efficiency

The economic efficiency objective of planning is the maximization of economic return to the nation in water and related land resources. Alternative project and program elements were examined that would achieve maximum benefits over costs in meeting the total needs. Only plan elements proposed for undertaking prior to 1980 were subject to benefit analysis. Projects and programs selected for construction or implementation after 1980 were based upon least cost and/or judgment with several alternatives usually presented.

Projections of employment for selected industries, total earnings, personal income, population and agricultural production have been made for the United States and the Puget Sound Area.[1] Inasmuch as these projections are based primarily on past trends, they reflect the pattern of national economic efficiency as it has developed under our system of enterprise and government. The economic efficiency objective is broad and in achieving it, much progress will be made toward meeting the environmental quality objectives.

To meet the objective of maximizing net economic returns and satisfactions from the economic resources, each element of the plan was formulated to include only segments or increments which would provide benefits at least equal to their cost. Plan formulation was considered complete when: (1) each separable segment or purpose provided benefits at least equal to its costs; (2) development was sized to provide the maximum net benefits, and (3) there were no more economical means of accomplishing the same purposes that would be acceptable to the public.

Environmental Quality

The environmental quality objective of framework planning is the maintenance or improvement of the quality of the area's environment. This objective includes not only preservation, but perhaps more important, positive measures to create an improved living environment. The inclusion of this objective would insure that the effects of water resource development on "human ecology," the relation between man and his environment, are carefully defined and evaluated. The extent to which the environmental quality objective is attained cannot always be expressed in monetary terms.

Proper long-run stewardship in each basin requires that certain areas be rehabilitated; that open space, green belts, wild rivers, lakes, beaches, mountains and related land areas be maintained and used for outdoor recreation; that recreation facilities be developed; and that areas of unique natural beauty, historical and scientific interest be preserved.

The economic efficiency objective includes evaluation of all needs. The environmental quality objective may be met in large measure by the economic efficiency objective. However, in some instances, available resources were not sufficient to meet all needs. In these cases, alternatives were prepared and presented so that informed choices could be made.

Because all Federal, State or local environmental quality objectives have not been specificially defined, judgment of the plannner served as the primary basis of determining when projects or programs were in conflict with the environmental quality objectives. Public expressions with regard to sites, areas and general attitudes, were given careful consideration.

Regional Development

The regional development objective of planning is the attainment of a desired pattern of regional income or development induced through water and related land resources investments. This objective is attained to the extent that such investments provide

[1] Appendix IV, Economic Environment.

specified patterns of regional development. Examples of regional development objectives are the desire to increase per capita income in an area and increase the total output and to enhance and utilize the economic potential of an area. The regional development objective is generally considered when basic economic problems of local nature are present that result in a situation of long-term high unemployment or dearth of job opportunities. The regional development objective was not considered to be appropriate to the Puget Sound Area because of the prospects for an expanding economy and the excellent long-range potential for future growth. Consequently, this objective was not explicitly recognized in the formulation of a comprehensive plan for the Puget Sound Area. The Plan is flexible in that elements can be shifted in the time scale to meet changing needs and objectives.

METHODOLOGY OF PLANNING

General

The planning for the Puget Sound Area began with public hearings and an inventory of water and related land resources and the development of projections of future economic development. These projections were translated into needs which were compared to available resource opportunities. From this comparison a plan was developed to satisfy the needs after considering alternative means to meet economic efficiency and environmental quality objectives and the viewpoints of the public. The planning procedures are covered in the following paragraphs.

Assessment of Local Viewpoints

Public hearings were held at Anacortes, Everett and Olympia in the fall of 1964. The testimony presented indorsed the study, especially the concept for coordination of effort and development of multiple-purpose use concepts for resource planning and development. Needs most frequently mentioned included municipal and industrial water supply, flood control, land stabilization and erosion control, navigation improvements and recreation needs, especially small boat moorages. A digest of these public hearings is given in Appendix I, Digest of Public Hearings.

Economic Evaluation of Present and Future Economy

Historical trends and economic activities were developed to a 1963 base utilizing studies made by the Consulting Services Corporation, the Economic Research Service and Forest Service of the U.S. Department of the Agriculture, and the Bureau of Mines of the U.S. Department of the Interior and other sources. Projections were made for 1980, 2000 and 2020 recognizing the natural resources of the Area and factors influencing its competitive advantages. The findings of these economic studies are presented in Appendix IV, Economic Environment.

Examination of the Environment

The political framework under which resources are administered was established in detail. The natural environment was examined with respect to water and related land. The broad land resources of the area were inventoried and the prospects for development were established. These studies are given in Appendices II through V.

Analysis of Water and Related Land Resources

Detailed studies were made for each of the major water and related land resource uses of the Puget Sound Area. Future needs for each resource use were determined by correlations with parameters projected in the economic base study, followed by the development of single-purpose plans to meet these needs.

The functional appendices contain single-purposes plans that were formulated to satisfy a particular need with minimal regard to the impact on other resource users. This was done in order to insure equal treatment and to obtain the maximum possible array of single-purpose alternatives. The results of these studies are given in Appendices VI through XIV.

Development of the Comprehensive Plan and Alternatives

The Comprehensive Plan provides for an early action and long-range development with a program covering projects and management requirements for each. The Plan was formulated to guide the water and related land resource management and development through the year 2020, recognizing that revisions and adjustments would be necessary in the future to allow for changing conditions and desires of the public. Development of the Comprehensive Plan proceeded along the following sequence:

(a) The needs as contained in the functional appendices were summarized in standard categories and expressed in output units similar to that used in

the Planning, Programming and Budgeting System. These needs, shown in Table 2-26 are net needs reflecting in most categories adjustments for existing levels of output from programs and projects. The net needs were generally derived by subtracting the present development from the total or gross needs.

(b) Alternative means of resource use were examined to satisfy the needs. The opportunities ranged from resource management to structural facilities development, including single-purpose and multiple-purpose solutions. Combinations of these solutions were utilized in developing a plan to meet the economic efficiency and environmental quality objectives of the study.

(c) A plan was formulated with initial investment costs and annual costs and benefits estimated for the early action projects needed by 1980. Only investment costs in terms of 1968 prices were estimated for the long-range portion of the plan providing for satisfaction of needs projected to the years 2000 and 2020. When conflicts arose between the environmental quality and economic efficiency objectives, adjustments were made where possible. Where the conflicts could not be resolved alternative plans or plan elements were prepared. The tentative projects and programs developed for each of the major river basins were presented to local planning and governmental authorities, including representatives of the counties and other interested groups, to determine their viewpoints. Every consideration was given to the local viewpoints and adjustments were made where appropriate.

CRITERIA FOR PLANNING

Legal Criteria

The Comprehensive Plan was developed in conformance with existing Federal and State laws, treaties, and compacts, recognizing that existing laws and compacts and departmental policy would not always allow optimum use of the resources.

Economic Criteria

Price Levels Price levels prevailing in 1968 were used for evaluating all present and future benefits and costs.

An interest rate of 4-5/8 percent per annum was used in plan formulation and evaluation for discounting future benefits and computing costs, or otherwise converting benefits and costs to a common time basis. This rate of interest is used upon the average yield during the preceding fiscal year on interest-bearing marketable securities of the United States with terms of 15 years or more remaining to maturity.

Period of Analysis and Life of Projects

A 100-year economic life was used in the analysis of projects proposed for development prior to 1980, which is normal for multiple-purpose storage projects. Projects having economic lives less than 100 years included replacements at the end of their normal lives.

The Comprehensive Plan was formulated to grow after 2020, and many of the proposed projects and programs, by adding facilities, will have the capacity to meet some of these needs. The potential of the Plan to meet needs that develop after 2020 has not been evaluated.

Basis for Comparison of Project Effects

Comparison and evaluation of the proposed projects and programs in the plan were made to determine the most effective use of water and related land resources. The value of the projects or programs included in the plan was determined on the basis of future conditions "with" the projects or programs included in the plan as compared to future conditions "without" the projects or programs included in the plan.

The future "with" conditions for individual project or program analysis include all economic development which would be expected to occur during the period of analysis with the project in existence.

The future "without" conditions include all projects that are existing or under construction as of 1968 and assuming adequate operation and economic growth was projected and includes future economic activity without specific projects.

Average Annual Equivalent Values

Program or project benefits and costs, which are estimated to accrue at different times and over varying periods of time, were converted from capital values to average annual equivalent values over a 100-year life.

The average annual costs and benefits of multiple-purpose projects were estimated for a 100-year life. However, in order to provide a common basis for comparison of nonstorage with storage alternatives,

an adjustment was made for projects that ordinarily have physical and economic lives of less than 100 years. This was accomplished by providing for major or complete replacement of these facilities at the end of their normal lives with an average annual equivalent replacement cost computed and included in the annual costs. Average annual equivalent costs for interest and amortization were computed with a capital recovery factor based on a 4-5/8 percent rate of interest. Average annual equivalent benefits were derived by projecting the benefits over a 100-year period and determining the present worth of future benefits with discount factors based on a 4-5/8 percent rate of interest.

Benefits

The ultimate aim of resource projects and programs, in common with all other productive activity, is to satisfy human needs and desires. Goods and services produced or provided to achieve this end have values in accordance with demand and availability. Benefits attributable to projects contained in the comprehensive plan are classified as primary or secondary and may be tangible or intangible. Primary benefits are considered the increase in value of goods or services or their protection directly as the result of a project. Examples of primary benefits are flood damage prevention; water supply for industrial, municipal or agricultural use; recreation; land enhancement and hydropower. Secondary benefits are values that accrue indirectly from the operation of a project such as relocation or creation of industry, increase in retail sales, per capita income, improvement of community cash flows or reversing the migratory trend toward large metropolitan areas. Tangible benefits which may be primary or secondary are values that are readily derived by comparison with other marketable goods or services. An example of tangible benefits is the prevention of flood damages to land and improvements, personal property and interruption of business. Intangible benefits, either primary or secondary, are values that are not readily subject to monetary evaluation except by assignment of arbitrary values or by assuming values equivalent to marketable goods and services. Intangible benefits include the saving of human life, maintenance or improvement of living conditions, alleviation of human suffering, and the safeguarding of wild and scenic rivers and of aesthetic conditions.

Primary Benefits

The primary tangible benefits, which are referred to as primary benefits, represent the estimated increase in the value of the actual goods, services, and satisfactions of a project or program expected for the period under study and from which any induced losses to other projects or programs have been deducted.

The benefits from domestic, municipal, and industrial water supply projects were assumed to be equal to the costs.

Primary benefits for irrigation projects were based upon income gains to farmers from increased crop production. Benefits for privately developed irrigation project systems were taken as equal to the costs.

Benefits of programs for vector (pest) control, solid waste collection and disposal, air pollution and radiation monitoring, and pollution abatement, watershed rehabilitation and protection measures, except storage for augmenting low streamflows, were assumed equal to the cost of these programs.

Benefits of navigation are recognized as savings in shipping time; the reductions in operation and maintenance costs; the increased value of any filled land obtained through spoil disposal; and economies of scale gained by use of larger and more efficient ships. Deep draft navigation benefits computed for this study were based on operational savings to project users as a result of reductions in delays due to tides, and land value enhancement gained from project dredged fill. Pleasure boating benefits from small boat harbor projects were included with general recreation benefits for purposes of plan formulation.

The primary benefits from hydroelectric power were based on the cost of equivalent power from thermal generating plants.

Primary benefits from control of overbank flood flows were derived from the differences in flood losses "with" and "without" protection.

The primary benefits from drainage and flood damage reduction, resulting from the upstream watershed projects, were derived from net values for expected changes in land use, the increased productivity of land, the reduction of direct damage to agricultural crops and fixed improvements, and reduction of management costs. For upstream watershed and local protection projects, enhancement and restoration benefits are also included where applicable.

Benefits used in the monetary evaluation of the recreation program consisted of the estimated value of increased user-days of recreational activity.

The primary benefits from the commercial fishery program were the estimated value of increased landings of commercial fish.

Primary benefits from the sport fisheries and wildlife program were taken as the estimated value of projected increases in user-days of fishing and hunting.

Secondary Benefits

Projects and programs relate to increased production of commodities that require additional raw materials, processing equipment, and more services to sustain the processing operation. These increased activities extend throughout the basins, Area and Nation. Project related recreation sport fishing, aesthetic, and wildlife development stimulate employment and monetary flows in the trade, service, and transportation industries. These impacts would particularly affect fishing camps, marinas, commercial boat docks, motels, sporting goods stores, service stations, boat dealers, restaurants, and many related businesses.

Costs

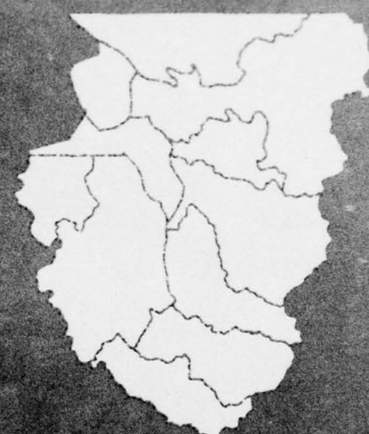
Costs of proposed projects and programs include the initial investment which would be incurred in one or more stages of construction and the annual expenditures required for operation, maintenance, and replacements. Investment costs include the capital expenditures associated with constructing a project and carrying out a program. Where the period of construction was estimated to be more than 2 years, the investment included simple interest on one-half of the construction costs for the period of construction. Capital investment and operation and maintenance costs of multiple-purpose projects were given a preliminary allocation to the several purposes served.

In addition to costs directly related to the construction and operation of a project, economic costs consisting of lost opportunities were considered. An example of an economic cost would be the loss of agricultural production from a valley that was flooded and used for reservoir purposes.

Intangible Costs

In evaluating resource projects and programs, many important effects cannot be adequately measured in monetary terms. Loss of aesthetic values is an example of an intangible cost frequently associated with resource development. Treatment of these intangible effects has been subjected to many of the requirements applicable to tangible effects. These included: (1) considering effects in terms of difference "with the project" and "without the project," and (2) considering intangible costs to the same degree or extent as intangible benefits.

Puget Sound Area



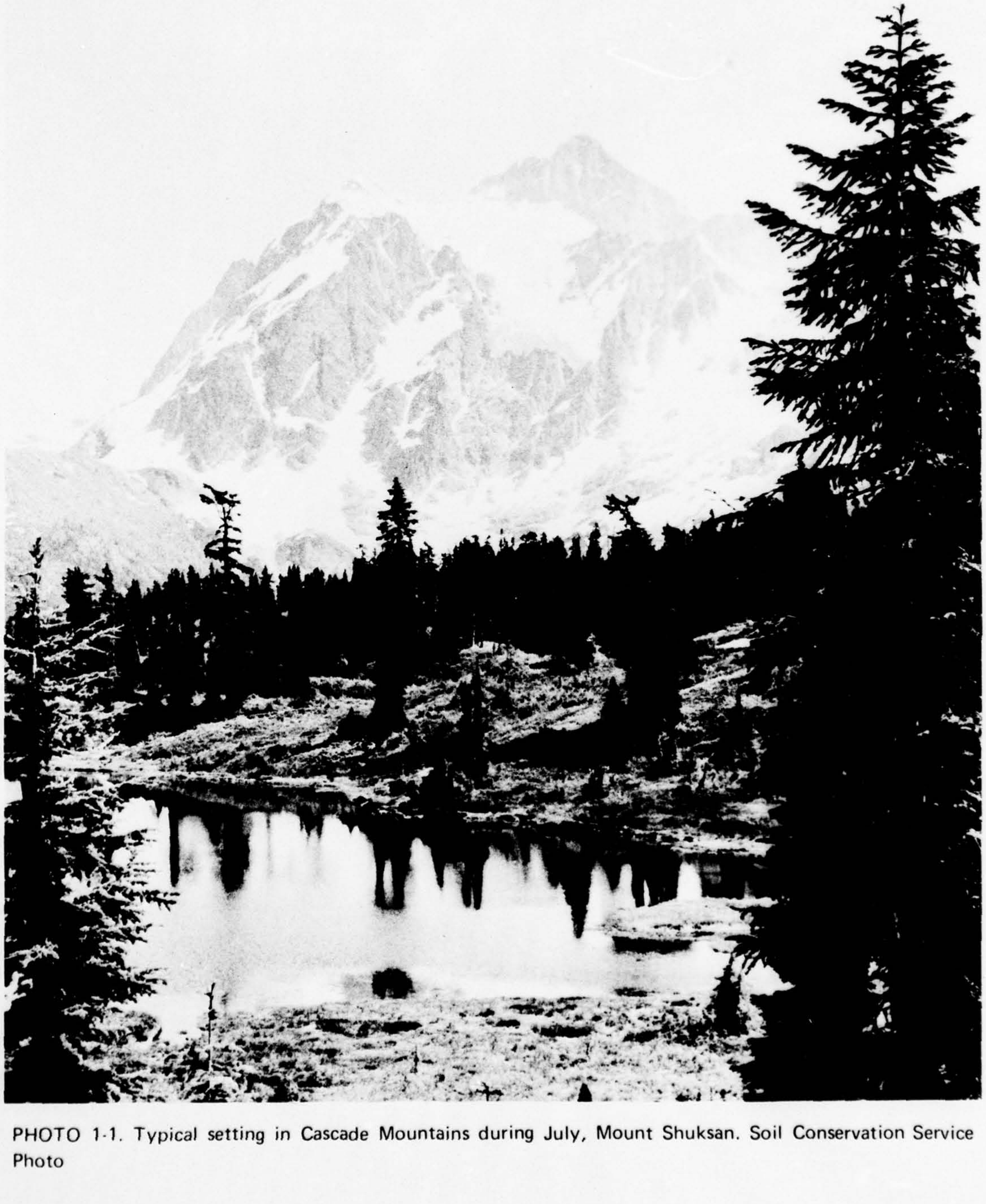


PHOTO 1-1. Typical setting in Cascade Mountains during July, Mount Shuksan. Soil Conservation Service Photo

PUGET SOUND AREA

LOCATION, DESCRIPTION AND HISTORY

The Puget Sound Area lies in northwestern Washington, bounded on the north by Canada, on the east by the Cascade Mountain range, on the west by the Olympic range, and on the south by low hills as shown in Figure 2-1. In the center of the Area is Puget Sound, an inland sea of 2,500 square miles with salt-water beaches and sheltered inlets along interior waterways. The Sound is nationally recognized for its scenic and recreational values, water transportation and for the production of fish, shellfish, and other marine resources. Wild land areas are located in the Cascade Mountains and on the Olympic Peninsula. The Area provides productive agricultural land, industrial sites, generally adequate water supplies, and extensive forests. Alluviated river valleys, bordered by bluffs and steep hills, constitute important physiographic features of the Puget Sound lowlands. The lowland valleys, with their mountain valley extensions, contain most of the population, industry, and agriculture in the Area. In the Cascade range the principal rivers head at elevations where precipitation is abundant and large amounts of snow accumulate each winter. The higher ridges generally reach an elevation of about 8,000 feet in the north and 5,000 feet in the south.

The Olympic Mountain range is generally lower in elevation than the Cascade range. The sharp peaks and ridges that characterize this mountain range reach elevations in excess of 6,000 feet. A "rain shadow" created by the Olympics, extends eastward from Port Angeles, nearly to Everett, and northward into the San Juan Islands. This area receives an average of 18 to 30 inches of precipitation annually as compared to 20 to 50 inches in other lowland areas and over 200 inches on the wettest slopes of the Cascade and Olympic Mountains. Most of the winter precipitation in the Puget Sound Area falls as rain at altitudes below 1,500 feet, and as rain or snow above the 1,500-foot elevation. Most rainfall is usually of light to moderate intensity over a long period of time rather than heavy for brief intervals.

In slightly more than 100 years the Area has emerged from a status of discovery and exploration with complete dependence on natural resources, to a modern, complex, technological society of the jet and nuclear age. Economic activity, including commercial fishing, transportation, agriculture, forestry, municipal and industrial development and recreation has evolved from modest beginnings. This transition from resource dependence to systematic resource management and development is recognized in the comprehensive planning for the Puget Sound Area.

RESOURCES

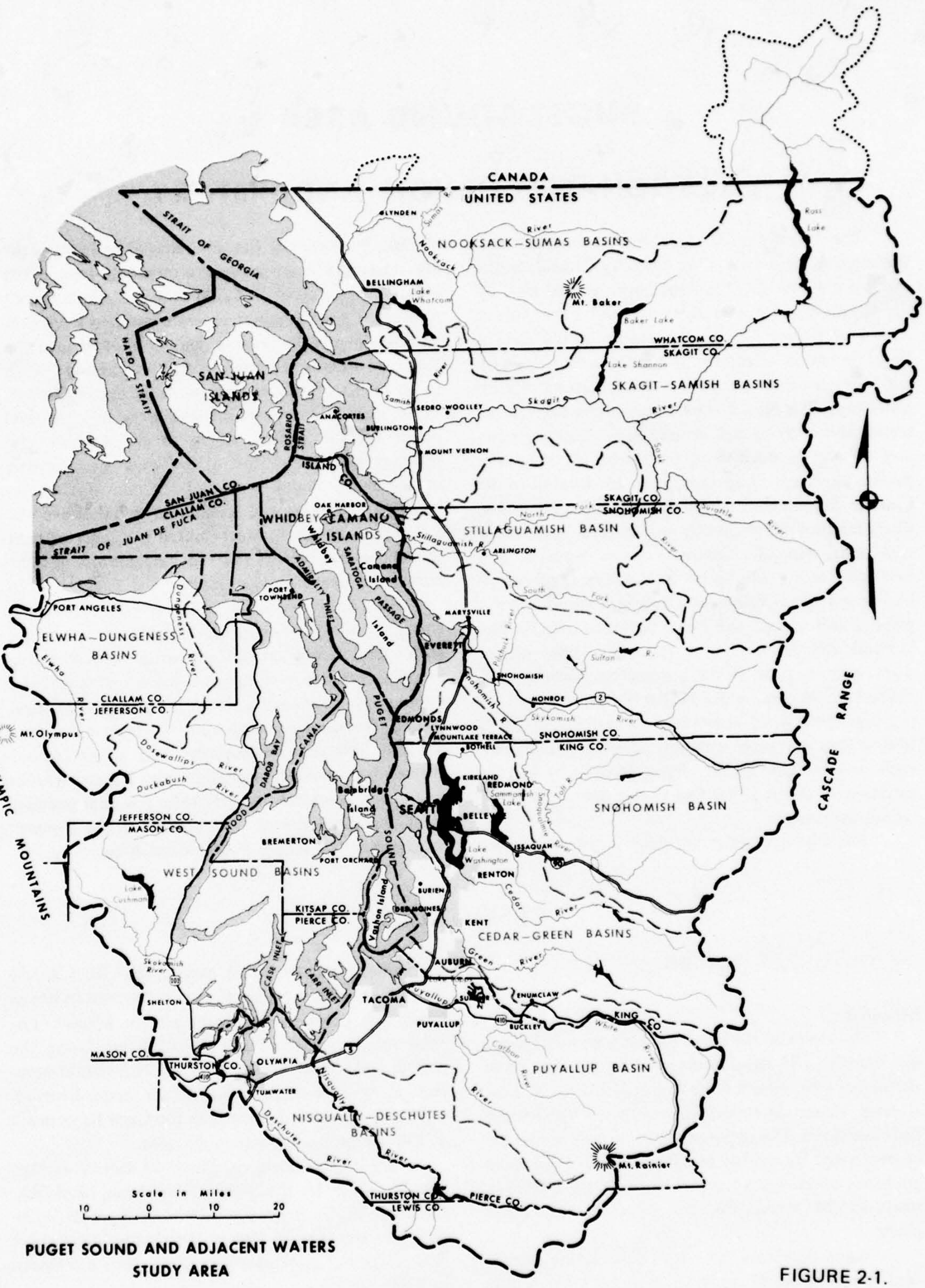
WATER

Streams

The rivers of the Puget Sound Area vary from a few miles to 135 miles in length. Glaciers, located at the higher elevations are the source for many of these streams, imparting stabilizing influences to summertime low flows. The upper portions of most basins are characterized by narrow mountain valleys with steep gradients which drain forested areas. In the lowlands, rivers exhibit meandering courses across the flood plains.

Major floods in the Area occur in the eastern and southern basins. Low streamflows occur during the summer months in all basins. The effect of low summer flows is most significant in the eastern basins where the demands for water are the highest. The total runoff for the Puget Sound Area during the period 1931-1960 averaged about 29,523,000 acre-feet per year. Average annual runoff ranges from 15 inches in some of the northern lowlands to as much as 140 inches in a few mountain areas.

The major rivers, in terms of largest average annual runoff, are the Skagit, Snohomish, Nooksack, Puyallup, Elwha, Nisqually, Green, Skokomish, Stillaguamish and Cedar Rivers. Discharge and runoff figures for various stations on these rivers are shown in Table 2-1.



PUGET SOUND AND ADJACENT WATERS STUDY AREA

FIGURE 2-1.

TABLE 2-1. Principal rivers, Puget Sound Area

Basin	River and Location	Drainage Area (sq. mi.)	Discharge (cfs) Minimum Daily Mean	Momentary Maximum	Average Annual	Average Annual Runoff (ac. ft.)
Nooksack-Sumas	Nooksack River nr. Lyndon	636	595	46,200	3,728	2,699,000
Skagit-Samish	Skagit River nr. Mt. Vernon	3,060 1*	2,740	144,000	16,340	11,830,000
Stillaguamish	South Fork, Stillaguamish River nr. Granite Falls	119	55	38,800	1,062	768,900
Snohomish	Snohomish River nr. Snohomish	1,720	2*	136,000	9,500	6,885,000
Cedar-Green	Cedar River nr. Renton	197	39	6,640	722	522,700
Cedar-Green	Green River nr. Auburn	382	81	28,100	1,334	965,800
Puyallup	Puyallup River at Puyallup	948	306	57,000	3,350	2,425,000
Nisqually-Deschutes	Nisqually River at McKenna	517	37	20,500	1,415	1,022,000
Nisqually-Deschutes	Deschutes River nr. Rainier	90	21	5,620	275	199,100
West Sound	Skokomish River nr. Potlatch	230	125	27,000	1,188	860,000
Elwha-Dungeness	Elwha River nr. Port Angeles	269	10	41,600	1,487	1,077,000
Elwha-Dungeness	Dungeness River nr. Sequim	156	77	6,820	371	268,600

1* Includes drainage area in Canada.

2* Flows less than 10,000 cfs not computed.

Source: Water Supply Bulletin No. 15, 1962 Washington Department of Conservation (Water Resources) and U.S. Department of the Interior, Geological Survey.

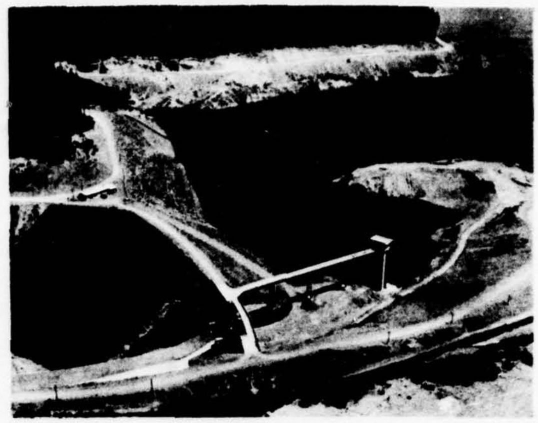


PHOTO 2-1. Howard A. Hanson Reservoir, a Corps of Engineers multiple-purpose project located 32 miles upstream from Auburn in the Green River valley, provides storage for flood control and low flow augmentation to enhance downstream anadromous fish production. Corps of Engineers Photo

PHOTO 2-2. Seward Park, located in Seattle on the western shore of Lake Washington, provides excellent opportunities for urban enjoyment of outdoor recreation activity. Corps of Engineers Photo

PHOTO 2-3. Port of Anacortes, located at the north end of Fidalgo Island, 93 nautical miles from the Pacific Ocean, services deep draft vessels carrying bulk petroleum, forest products and general cargo. Port of Anacortes Photo

Streamflow characterisitics and other data related to hydrology of the Area are discussed in Appendix III, Hydrology and Natural Environment.

Ground Water

High yields of ground water can frequently be obtained in the lower valley floor and adjacent to the delta of the rivers and tributaries in the Area. Ground water yields are relatively small in the mountainous areas. Aquifers occur in gravel and sand deposits of recessional (Fraser) glacial outwash and alluvium. These aquifers usually contain fresh water at depths of as much as a few hundred feet below sea level except in near-shore areas where aquifers less than 200 feet deep may contain sea water. The aquifers that contain fresh water receive usually undefined quantities of recharge through infiltration of precipitation principally during winter months. The magnitude of recharge as well as the capacity of aquifers is not presently known.

Scattered ground water quality problem areas exist as a result of excessive concentrations of several constituents—notably iron, nitrate, and hardness elements—and localized bacterial contamination. Other than these scattered problems quality of the ground water is generally high.

Lakes and Reservoirs

The total amount of storage in the 2,808 lakes and reservoirs in the Puget Sound Area is not known, however, the surface area of these water bodies is at least 175 square miles. This area includes 24 major reservoirs having a surface area of about 70 square miles. Ross Reservoir on the Skagit River is the largest, having a total surface area of 11,820 acres. The largest lakes are Lake Washington (22,138 surface acres), which forms the eastern city limits of Seattle, and Lake Sammamish (4,897 surface acres), approximately five miles directly east of Lake Washington. Many of the other lakes are small and located in mountainous country above 2,500 feet in elevation. Most of these are high alpine lakes of exceptional beauty, lying in a wilderness of scenic grandeur. Lowland lakes are rapidly being developed for residential and recreational use and water quality problems associated with these uses are demanding increasing attention.

Estuaries

Estuaries are the transitional zones where rivers meet the sea. The mixing of fresh and salt waters results in a unique, variable and delicate environmental system. Salt marshes, bays, channels and inshore waters are part of the estuarine zone which is of importance to fish. It is through this zone that young salmon must adjust to the new marine environment. The adjustment is a critical period, and good quality water is a requirement to accomplish a successful transition.

A rich and varied ecosystem of aquatic, mud flat and marsh habitats is supported by the estuaries with adjacent lowlands often providing habitat for wildfowl. Some estuarial areas in Puget Sound approach a natural state and are unique outdoor laboratories for study and research of the complex interactions of living organisms. A few, like the Duwamish, Snohomish and Puyallup have been encroached upon by the expansion of cities and the growth of industries.

Marine Waters

The waters confined within the boundaries of Puget Sound are actually a small portion of a larger marine complex that includes the Strait of Georgia and the Strait of Juan de Fuca. The entire complex is composed of many interconnected inlets, bays, and channels with sea water entering from the west and fresh water entering at many points throughout the system. This large complex may be divided into nine major oceanographic areas which are interrelated: Strait of Juan de Fuca, Admiralty Inlet, Puget Sound Basin, Southern Puget Sound, Hood Canal, Possession Sound, Bellingham Bay, San Juan Archipelago, and Georgia Strait.

Basically, the Puget Sound–Georgia Strait-Juan de Fuca Strait complex is a two-layer system with fresher water moving seaward in a surface layer that overrides a more saline layer of inflowing oceanic water. The surface layer contains fresh water added locally from direct precipitation, river runoff, and other land drainage. The deeper, more saline layer moves landward in response to the forces associated with the difference in density between fresh water and sea water.

The Puget Sound Basin extends from the south end of the Admiralty Inlet to the north end of the Tacoma Narrows and is 50 miles long, averaging 5 miles in width. There are several suboceanographic areas which include Elliott Bay, Commencement Bay, Colvos Passage, and the waters west of Bainbridge Island. Each of these sub-areas is closely related to the main basin but with somewhat different surface

characteristics. The major differences are due to the source and amount of fresh water entering the sub-area.

Southern Puget Sound consists of all the waters south of the Tacoma Narrows. Currents are very strong in the Narrows, with speeds up to 7 miles (6.08 knots) an hour being common. The Narrows is a mixing zone similar to Admiralty Inlet on a smaller scale. In this case, waters from either side to depths of about 160 feet are mixed, depending upon the tide direction. Complete top to bottom mixing occurs during most of the tide cycle.

Hood Canal is a long, narrow inlet extending some 70 miles from Admiralty Inlet on its northern end to Lynch Cove to the south. The major fresh water sources for Hood Canal are the Skokomish, Hamma Hamma, Duckabush, and the Dosewallips Rivers. They exhibit a peak discharge in winter in response to local rainfall, but the largest discharge occurs in June because of snow melting in the mountains. A rather thick (15 feet) fresh surface layer is produced that overlies all the main body of water.

The marine waters of the Puget Sound Area are discussed in detail in Appendix XIII, Water Quality Control.

LAND

There are 13,200 square miles of land within the 15,800 square-mile Puget Sound Area. There are striking contrasts in types of terrain. The lowlands contrast markedly with the mountains of the Olympic and Cascade Ranges, which form the Area's western and eastern borders. The southern border is a low divide that separates the Puget Sound Area from the Chehalis River Basin.

The lowland valleys, with their mountain valley extensions, contain most of the population, industry and agriculture. The valleys are separated by uplands whose gently rolling surfaces are altered segments of a formerly continuous plain. Terraces, lakes, and marshy depressions diversify the terrain on the uplands. In much of the Area there is an abrupt transition from these broad, hilly uplands to mountains.

PRESENT SITUATION

ECONOMY

In 1967, the 2.0 million people in the Puget Sound Study Area comprised nearly two-thirds of the total population of the State of Washington. Of this, nearly 90 percent lived in and around the rapidly growing Everett-Seattle-Tacoma metropolitan complex located in the Snohomish, Cedar-Green and Puyallup Basins. The northern basins, including the Nooksack-Sumas, Skagit-Samish, San Juan and Whidbey-Camano; and the western basins, including the Nisqually-Deschutes, West Sound and Elwha-Dungeness are generally rural in nature and accommodate the remaining 10 percent of the population.

Table 2-2 compares the growth of population in various areas for the period of 1910 through 1967.

TABLE 2-2. Historical population trends, United States, Washington and Puget Sound Economic Area 1910-1967 (thousands)

	1910	1940	1960	1967
United States	92,228	132,164	179,323	200,100
Washington	1,142	1,736	2,853	3,203
Puget Sound Economic Area	607	1,007	1,768	2,033
North Division	(87)	(107)	(144)	(156)
Central Division	(482)	(820)	(1,513)	(1,751)
West Division	(38)	(80)	(111)	(126)

Source: Appendix IV, Economic Environment.

PHOTO 2-4. Pier 46, general cargo container terminal at Port of Seattle. Nearly 3,000,000 short tons of foreign and domestic coastwise and domestic internal general cargo were handled by the port in 1966. Waterborne commerce is an important segment of the Puget Sound Area economy. Port of Seattle Photo

PHOTO 2-5. Beef cattle grazing on improved clover-grass pasture in Sauk River Basin. The 1963 cattle and calve production in the Puget Sound Area was valued at in excess of $16,000,000. Soil Conservation Service Photo

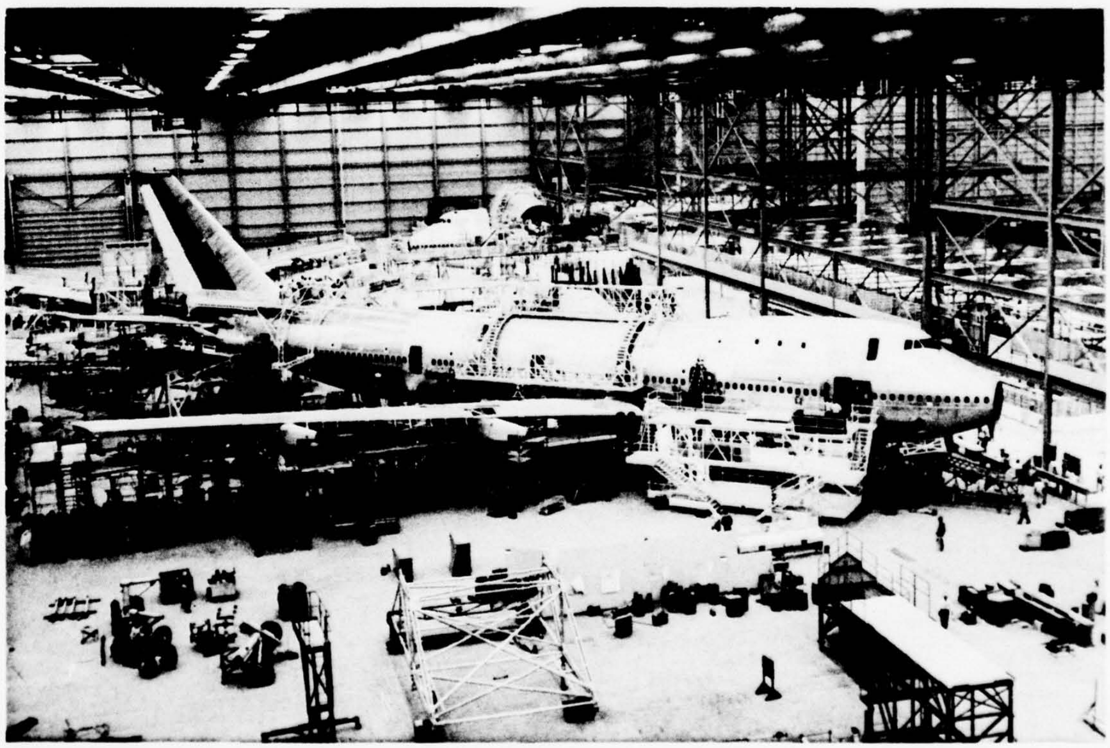


PHOTO 2-6. Production of Boeing 747 super transport jet airplane at Paine Field, near Everett. The aerospace industry has been a major contributor to the Area's economy with 95,000 persons employed by Boeing in the State of Washington in 1968. The Boeing Company Photo

The Puget Sound Economic Area, comprising all of the following counties, was divided into three divisions:

North Division	Central Division	West Division
Whatcom	Snohomish	Clallam
Skagit	King	Jefferson
Island	Kitsap	Mason
San Juan	Pierce	Thurston

This division was necessary to conform with availability of essential economic data. The difference in economic activity between the Hydrologic Area and the Economic Area is nominal due to the sparse population and large Federal land holdings.

The most intensive land use is concentrated in the Central Division, which includes the Seattle-Tacoma-Everett metropolitan and industrial areas, as well as numerous small cities and suburban residential developments that comprise approximately two-thirds of the total urban land. The Seattle-Tacoma-Everett metropolitan area functions as the major shipping, trading and manufacturing center in the Puget Sound Area and includes major seaports with some of the finest natural deep-water facilities in the world for ocean-going vessels. The Central Division supports a heavy industrial complex oriented toward aerospace, shipbuilding, trade, transportation, and diversified manufacturing. Defense facilities, such as Fort Lewis, McChord Air Force Base and the military complex of the Bremerton Naval Shipyard are major sources of economic income to the Puget Sound Area.

In the West Division the waters of the Strait of Juan de Fuca support an abundance of marine-oriented recreation and fish and wildlife. Water-oriented commercial and recreational activities are important elements in the economy. Mountains, forests, lakes and rivers are within a short distance for recreationists and tourists. As a result, trade and service industries are expanding in terms of employment, facilities and programs to meet the present and anticipated needs of recreation.

The North Division accounts for 30 percent of the Area's commercial forestland, most of which is in Skagit and Whatcom Counties. Agriculture, timber production and fishing and related activities have long been important to the economy. Important factors in recent population growth may be attributed to the manufacture of food and kindred products, lumber, wood and chemical products, oil refining, and iron and steel manufacturing. Recreation, including boating, stream and lake fishing, and other water, forest and mountain activities are important activities.

In the six-year period (1960-1966) the average annual growth of employment of 3.7 percent made the Puget Sound Area one of the fastest growing areas in the United States. The national rate of growth during this period was 1.5 percent. The most significant upward trend has been in the category of other durable manufacturing, which includes aerospace and shipbuilding. Table 2-3 shows employment in the Puget Sound Economic Area for 1960, 1963 and 1966 in 14 industrial sectors and by divisions.

TABLE 2-3. Employment by major industries, Puget Sound Economic Area and Divisions 1960, 1963 and 1966 (thousands)

	1960				1963				1966				Average Annual Increase	Central Division Percent of Total
	North	Central	West	Total	North	Central	West	Total	North	Central	West	Total		
Ag., For., Fish., & Mining	7.3	15.3	2.4	25.0	7.1	14.0	2.6	23.7	7.0	12.3	2.7	22.0	-2.1	56
Construction	4.0	32.2	1.6	37.8	2.8	36.3	2.1	41.2	4.3	43.7	2.0	50.0	4.8	87
Food & Kindred	2.2	13.3	0.9	16.5	2.4	12.6	0.9	15.9	2.1	13.1	0.9	16.1	-0.4	81
Forest Products Ind.	3.3	20.3	7.3	30.9	3.2	19.9	5.9	29.0	3.4	21.1	7.6	32.2	0.7	66
Chemicals	0.0	2.2	0.1	2.3	0.0	22.2	0.1	2.3	0.2	2.2	0.1	2.4	0.7	92
Petroleum	1.2	0.2	0.0	1.4	1.0	0.2	0.0	1.2	0.9	0.2	0.0	1.2	-2.5	17
Stone, Clay & Glass	0.4	2.9	0.1	3.4	0.4	3.3	0.1	3.8	0.4	3.4	0.1	3.9	2.3	87
Primary Metals	0.0	3.8	0.0	3.8	0.0	4.1	0.0	4.1	0.4	4.8	0.0	5.2	5.4	92
Other Non-Durable	0.7	13.5	0.5	14.7	0.7	13.8	0.5	15.0	0.7	16.0	0.6	17.3	2.8	93
Other Durable	0.7	77.7	0.3	78.7	0.8	85.2	0.2	86.2	1.2	116.0	0.3	117.5	6.9	99
Trans. Comm. & Pub. Ut.	2.1	36.3	1.4	39.8	2.1	36.7	1.5	40.3	2.3	41.5	1.7	45.5	2.3	91
Trade	8.3	119.3	5.9	133.5	8.3	125.3	6.3	140.0	9.6	142.9	7.8	160.3	3.1	89
Service	8.6	115.9	6.1	130.6	8.4	128.3	7.3	144.0	9.3	149.9	8.0	167.2	4.2	90
Government	7.5	88.5	9.7	105.8	8.3	97.2	10.2	115.8	9.1	113.1	11.2	133.3	4.0	85
Total	46.5	541.0	36.3	623.9	45.6	578.5	38.8	663.1	51.1	680.3	43.2	774.5	3.7	88

Source: Appendix IV, Economic Environment.

Table 2-4 shows employment and sales of non-commodity industries in 1963.

TABLE 2-4. Employment and sales of non-commodity industries, Puget Sound Economic Area 1963 (1963 dollars)

Industry	Employment (1000's)	Output (millions of dollars)
Service[1]	144.0	$1,149.5
Wholesale & Retail Trade	140.0	1,250.3
Government	115.8	--
Construction	41.2	673.8
Transportation, Communication, & Public Utilities	40.2	615.6
Total	481.2	$3,689.2

[1] Includes finance, insurance, real estate, hotels, motels, etc.

Source: Exhibit D, Appendix IV, Economic Environment.

Following the national trend, growth in wholesale and retail trade has been rapid with the utilization of consumer self-service and other labor saving devices. As a result the volume of sales per employee has increased greatly due to more efficient operating procedures. The service sector which includes restaurants, motels, finance, insurance and real estate and other personal services has had a rapid growth due to increased personal incomes, growing population and a rising demand for personal services.

Although recreation and tourism affect all types of industries, the service sector is the prime beneficiary. More people, higher incomes, increase in leisure time and greater mobility are among the pertinent reasons for growth. Outdoor recreation and tourism is particularly important to the Area. In 1959 almost six million out-of-state travelers had expenditures of almost one quarter billion dollars in the State of Washington. The 1962 Seattle World's Fair tourist expenditures were over $3 billion. The unique combination of sea and mountains attracts many tourists and recreationists and provides for additional employment and sales.

Per capita income in the Puget Sound Economic Area was greater than the Pacific Northwest and the Nation in both the 1950-51 and 1960-61 periods. The Central Division held the lead over the Study Area, the Pacific Northwest, and the Nation in both the time periods. However, the North Division and the West Division had less per capita income when compared with the same major areas in the same time periods. Per capita income for the period 1960-61 was $2,526 for the Area compared to $2,227 for the Pacific Northwest and $2,249 for the United States. The per capita income for this same period was $1,941 for the North Division, $2,622 for the Central Division and $1,962 for the West Division.

The present economy has emerged from the age of discovery and settlement with abundant resources to a period requiring planned development along with mangement in order to properly use and conserve the resources of the Area. Foreseeable demands on all resources in the Area indicate a need for accelerated planning to properly coordinate land and water development.

WATER USE

The largest consumptive uses of water in the Puget Sound Area are for municipal and industrial purposes. Other water uses include diversion for irrigation, electric power generation, operation of fish hatcheries, recreation areas and forest product mills. The instream uses of water are important for fish, recreation, water quality and navigation.

The 1965 municipal and industrial water use was approximately 660 million gallons of water per day. Nearly two-thirds of this consumption occurred in the Tacoma, Seattle, and Everett metropolitan areas. Although surface sources supply 85 percent of the municipal and industrial use, ground water is an important source in many basins.

The municipal use averaged 220 million gallons daily or approximately 135 gallons per capita per day. Industrial water use averaged about 430 mgd which represents about 65 percent of the total used by municipal and industrial consumers. Of this amount, about 95 percent was supplied from surface water sources.

Table 2-5 summarizes the 1965 municipal and industrial water use.

A relatively small portion of the Area (about 91,700 acres) is presently irrigated. Due to the moist climate, irrigation is primarily used to prevent crop failure and to maintain plant growth rather than to produce optimum yields. The amount of water diverted for irrigating the 91,700 acres is estimated to

TABLE 2-5. Summary of Puget Sound Area water uses (1965)

Use	Surface Water			Ground Water			Total		
	Estimated population served	Usage (mgd) Average daily	Usage (mgd) Maximum monthly	Estimated population served	Usage (mgd) Average daily	Usage (mgd) Maximum monthly	Estimated population served	Usage (mgd) Average daily	Usage (mgd) Maximum monthly
Municipal	1,356,550	165	231	467,000	53	151	1,823,550	219	382
Rural Individual	14,450	1	1	134,700	8	12	149,150	9	13
Industrial		408	455	—	24	31		432	486
Total	1,371,000	575	687	601,700	85	194	1,972,700	660	881

Source: Appendix VI, Municipal and Industrial Water Supply.

be about 228,000 acre-feet annually of which 83,000 acre-feet or 33 percent is obtained from ground water sources.

There are no established minimum flow requirements, at present, on any of the streams in the Area for water quality purposes. However, minimum flows are being established by the State on select streams.

The natural deep water channels of Puget Sound permit any size vessel to enter from the Pacific Ocean to the many ports located in the Area. This, plus the strategic location of the Sound with respect to Alaska and the Orient, has made waterborne commerce of major importance. Puget Sound is one of the few natural areas in the Nation which has the channel and port depths to handle the super-ships beginning to ply the waterways of the world. Nearly every river in the Area is by definition, navigable. However, only the lower sections, generally within the tidal range, are actually used for navigation. Total foreign and domestic coastwise and domestic internal waterborne commerce was about 40 million tons in 1966 with the annual growth from 1952 and 1966 averaging about 2.5 percent.

The rivers in the Puget Sound Area have been a source for obtaining electric energy since a small water power plant was placed in operation on a small unnamed stream at Tacoma in 1886. A total of 1.25 million kilowatts are presently installed in the Puget Sound Area in 22 hydroelectric power developments. The water diversions for the hydroelectric power plants range from 5 cfs for the smallest plant to 9,500 cfs for the largest.

There are several thermal-electric steam plants in the Puget Sound Area. These are located on Lake Union and Lake Washington, the Duwamish River, Tacoma and directly on the Puget Sound.

Local sources of power are inadequate to supply the present power demand and two-thirds of the peak demand is supplied from outside sources, primarily the Columbia River.

The physical features of the Puget Sound Area with its high mountain lakes, numerous rivers and streams and marine waterways make it an important water related recreation area. Pleasure boating opportunties in the San Juan Islands and the numerous marine waters of Puget Sound are outstanding. Swimming and water skiing are popular activities often associated with camping or picnicking.

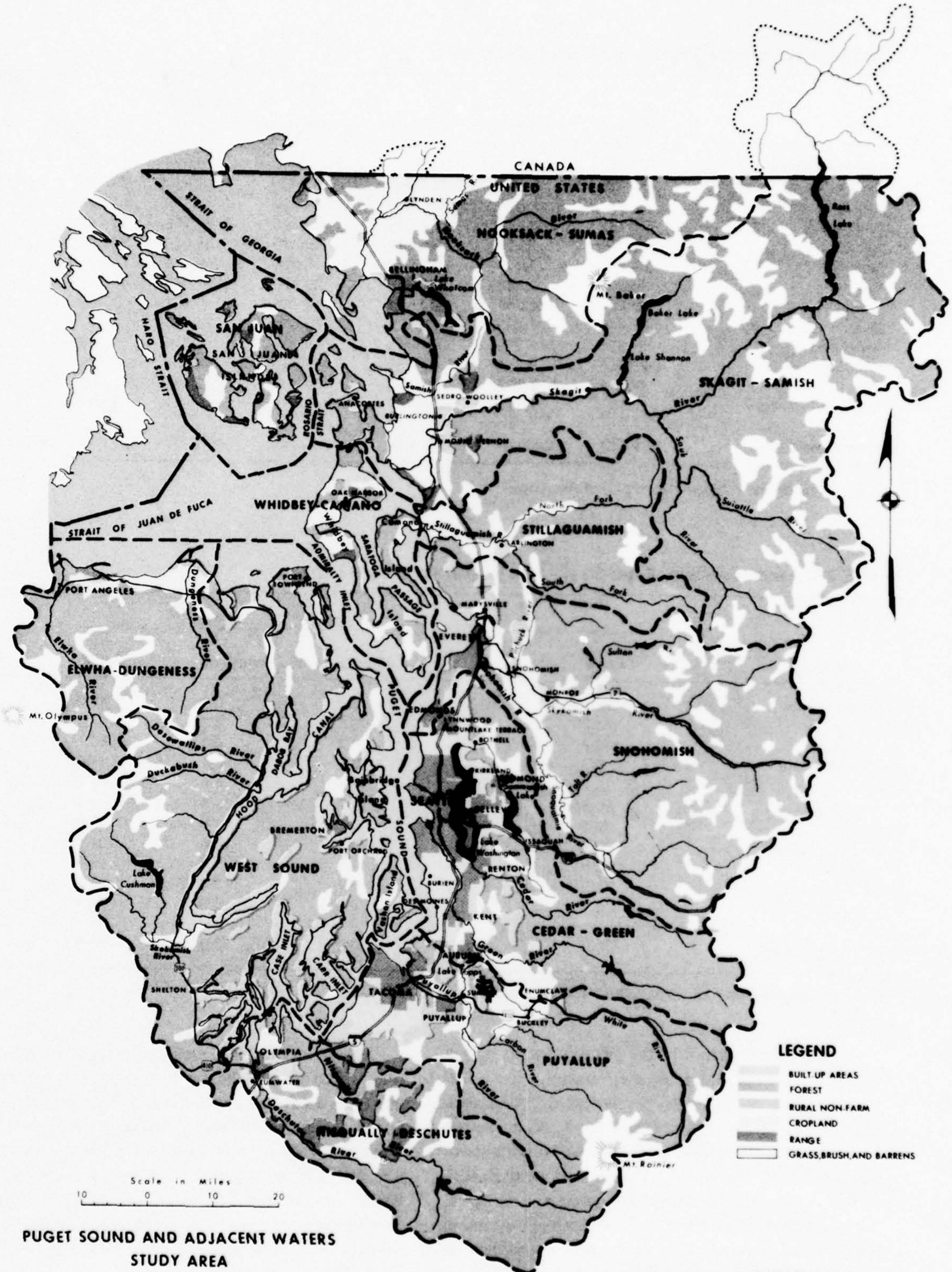
The waters of Puget Sound are rich in nutrients and support a wide variety of marine fish and shellfish species. Many of the fish that reside or migrate through Puget Sound waters are of significant value to sports and commercial fishermen. An estimated 2,820 miles of stream are utilized by anadromous fish for spawning and rearing throughout the Area.

The anadromous fish of the Area include chinook, coho, sockeye, pink and chum salmon, and steelhead, searun cutthroat, and Dolly Varden trout. All of these fish spend a portion of their lives in the saltwaters of Puget Sound and the Pacific Ocean before returning to streams of origin to spawn. The juveniles of these fish spend varying amounts of time in the shore waters of the Area and in the shore waters of the Sound before moving to sea to grow to maturity.

The most intensive fresh-water salmon and steelhead fish areas are located in Green, Stillaguamish, Puyallup, and Skagit Rivers. The Green and Puyallup are in the most heavily populated areas and are readily accessible by roadways.

LAND USE

General land use is shown in Table 2-6 and on Figure 2-2 for the Area. Each Basin section presents a more detailed land use map. Ownerships are shown in Table 2-7.



PUGET SOUND AND ADJACENT WATERS
STUDY AREA

FIGURE 2-2.

Generalized Land Use

TABLE 2-6. Land use, Puget Sound Area 1967 (in acres)

Basin	Cropland	Rangeland	Forest Land	Rural Non-Agricultural	Built-Up Areas	Fresh Water	Total Area Land and Fresh Water
Nooksack-Sumas	137,492	11,600	609,581	12,669	20,896	12,129	804,367
Skagit-Samish	100,465	19,748	1,753,445	20,092	18,804	35,409	1,947,963
Stillaguamish	34,531	1,016	385,450	5,932	6,698	4,721	438,348
Snohomish	71,752	2,424	1,054,699	29,360	36,355	23,861	1,218,451
Cedar	20,279	1,120	210,641	25,379	106,516	32,888	396,823
Green	33,103	2,232	236,047	8,966	59,885	5,950	346,183
Puyallup	36,853	5,683	593,339	25,729	97,446	11,297	770,347
Nisqually	29,254	34,008	379,675	6,368	5,481	7,468	462,254
Deschutes	16,248	9,480	127,123	13,541	14,416	2,597	183,405
San Juan	18,594	9,129	71,958	9,118	2,774	955	112,528
Whidbey-Camano	23,006	2,454	84,069	12,419	10,987	719	133,654
West Sound	46,215	5,137	1,123,666	64,208	42,161	12,606	1,293,993
Elwha-Dungeness	23,721	2,417	409,491	5,073	5,911	1,844	448,457
Puget Sound Area	591,513	106,448	7,039,184	238,854	428,330	152,444	8,556,773

Source: Appendix V, Water-Related Land Resources.

TABLE 2-7. Land ownership, Puget Sound Area (in percent of total area)

Basin	Public					Private
	Federal	State[1]	County	Municipal	All Public	
Nooksack-Sumas	34.3	10.7	0.3	0.6	45.9	54.1
Skagit-Samish	71.2	5.5	0.1	0.3	77.1	22.9
Stillaguamish	40.2	16.4	0.2	0.3	57.1	43.0
Whidbey-Camano	6.1	4.3	0.5	0.1	11.0	89.0
Snohomish	35.4	11.7	0.1	4.5	51.7	48.3
Cedar-Green	10.3	3.3	0.2	15.6	29.4	70.6
Puyallup	39.4	2.5	0.1	1.6	43.6	56.4
Nisqually-Deschutes	20.7	9.8	0.2	0.6	31.3	68.7
West Sound	28.5	9.4	0.1	1.4	39.4	60.6
Elwha-Dungeness	75.3	6.1	0.1	0.4	81.9	18.1
San Juan	1.1	8.3	0.8	0.0	10.2	89.8
Puget Sound Area	40.8	7.9	0.2	2.6	51.5	48.5

[1] Figures include country trust land administered by the State of Washington.

Forests are currently the primary use of land in the Puget Sound Area as they occupy some 7.0 million acres, or about 80 percent of the total area. The Skagit-Samish, Snohomish and West Sound Basins contain the largest acreage of forest with about 55 percent of the Area's total. Forest land classification shows 13 percent of the acreage in noncommercial forest; 9 percent held in reserved status in parks, wilderness, or lake units; and 78 percent in commercial forest land capable of and available for the production of forest products.

Agricultural land, including rangeland and cropland, make up 698,000 acres, or about 8 percent of the total area. Agriculture is largely confined to the fertile lowland and inland valley areas which are utilized for fruit, berry and vegetable growing, and for dairying and poultry raising operations. The Basins containing the most intensive agricultural development include the Nooksack-Sumas, Skagit-Samish, and Snohomish, Cedar-Green, Puyallup and Elwha-Dungeness Basins.

Urban, industrial and other intensively developed land approximate another eight percent of the area, covering about 667,000 acres. This includes 239,000 acres of rural nonagricultural lands and 428,000 in built-up areas. Intensive development has occurred in the lowlands adjacent to Puget Sound and along the established transportation routes within the Area. Heavy industry is concentrated along the shorelines of bays and estuaries, particularly Commencement and Elliott Bays, Possession Sound, and the lower reaches of the Duwamish River. Other intensive development is occurring around the periphery of the established metropolitan areas, particularly in the lower reaches of the Snohomish, Cedar, Green and Puyallup River valleys. In many instances, such development has occurred on high value agricultural land in these basins.

The remaining nine percent of the Area is made up of fresh water surface, open and barren lands, and land not otherwise classified.

The overall ownership of land in the Puget Sound Area is almost evenly divided between public and private owners, ranging from extremes of 82 percent public in the Elwha-Dungeness Basin to 90 percent private in the San Juan Islands. Most public land is located in the mountainous areas under Federal jurisdiction, composed mainly of the national forests and national parks. Other significant blocks of public land include State ownerships in the Nooksack-Sumas, Stillaguamish and Snohomish Basins; and the City of Seattle ownership in the Cedar-Green Basin.

PROJECTED ECONOMY

Projections of the economy for the Puget Sound Area for the years 1980, 2000 and 2020 are detailed in Appendix IV, Economic Environment. The findings of this appendix form the basis for projecting the needs for water and related land resources. The major elements of these projections are summarized in the following paragraphs.

Population in the Puget Sound Area is projected to be 2.7 million persons by 1980 and 6.8 million by the year 2020 (See Figure 2-3). Population growth is expected to be greatest in the Seattle-Tacoma-Everett metropolitan complex. Table 2-8 shows the population projection for each of the eleven major basins of the Puget Sound Area.

The greatest population growth is projected to occur in the Cedar-Green, Puyallup, Snohomish and West Sound Basins. By 1980, these four basins are expected to have some 2.4 million people and account for 88 percent of the total population. Present trends point to a continued concentration of population in these basins, with over five million people expected by 2020.

Table 2-9 shows the Gross Regional Product and Employment projections by industry. Employment by 1980 is projected to approach one million jobs, with the Gross Regional Product almost doubling to 11.4 billion dollars (1963 dollars). Gross Regional Product per person is expected to increase some 34 percent over the 17-year period.

The large water using industries (Food and kindred products, paper and allied products, chemical and petroleum, primary metals, stone, clay and glass, and lumber and wood products) are expected to experience susbstantial growth. Production for the major water-using industries is expected to realize an 82 percent increase from 1965 to 1980 in terms of value added. Food and kindred products, paper and

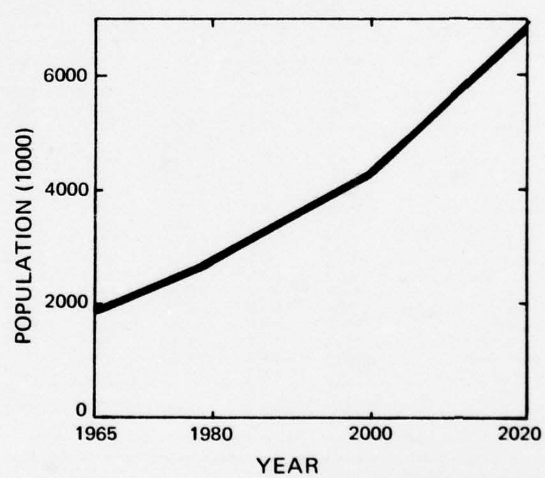


FIGURE 2-3. Projected population growth for the Puget Sound Area.

Source: Appendix IV, Economic Environment.

TABLE 2-8. Population projections by basins, Puget Sound Area (in thousands)

Basin	1963	1980	2000	2020
Nooksack-Sumas	74.6	91.6	123.5	168.7
Skagit-Samish	53.8	64.2	86.5	118.2
Stillaguamish	17.6	30.2	48.5	77.8
Whidbey-Camano Islands	19.9	56.0	80.9	115.0
Snohomish	178.2	297.8	467.8	761.4
Cedar-Green	976.9	1,454.8	2,270.0	3,619.9
Puyallup	324.5	449.8	700.0	1,107.5
Nisqually-Deschutes	69.6	74.9	104.5	146.5
West Sound	124.2	175.0	374.1	632.7
Elwha-Dungeness	28.3	29.8	41.0	56.6
San Juan Islands	2.6	2.8	3.7	5.1
Puget Sound Area	1,870.0	2,726.9	4,300.5	6,809.4

Source: Appendix IV, Economic Environment and Appendix V, Water-Related Land Resources.

allied and primary metals are projected to lead this growth. Relatively large increases also are projected for the chemicals and petroleum industries. On the declining growth side is the lumber and wood products industry.

Recreation and tourism are major industries. By 1980, over 109 million recreation days are forecast for the Puget Sound Area. Water-related activities are expected to account for over 45 percent of this total outdoor recreation demand in 1980. Intense recreation is expected to occur in the Cedar-Green, Snohomish, West Sound, and Puyallup Basins. These four basins are projected to account for about 63 percent of the total outdoor recreation demand estimated for 1980.

TABLE 2-9. Present and projected output, value added, employment by industry and population, Puget Sound Area

Industry	1963			1980			2000			2020		
	Output[1]	Value Added[2]	Employment	Output[1]	Value Added[2]	Employment	Output[1]	Value Added[2]	Employment	Output[1]	Value Added[2]	Employment
	Millions of 1963 $			Millions of 1963 $			Millions of 1963 $			Millions of 1963 $		
Agri., Fish., For., Mining	196.7	99.5	23,700	261.1	139.0	18,200	360.0	190.0	13,500	516.0	268.0	11,000
Food & Kindred Prods.	698.5	223.3	15,900	1,240.9	405.3	19,500	2,333.4	900.2	22,900	4,088.7	1,906.6	25,600
Lumber & Wood Prods.	413.7	174.6	19,700	371.3	154.6	8,300	305.5	146.0	2,800	234.2	136.0	900
			(21,500)			(17,000)			(14,700)			(12,600)
Paper & Allied Prods.	349.2	168.1	9,400	683.1	334.9	14,700	1,009.4	561.0	15,900	1,101.5	705.1	12,400
			(9,800)			(10,300)			(10,900)			(9,300)
Chemicals	70.4	33.9	2,300	138.6	68.4	1,900	287.0	170.4	1,400	553.7	420.2	1,000
Petroleum Refining	255.9	61.5	1,200	511.8	123.0	1,300	1,080.2	301.4	1,400	2,124.7	729.1	1,300
Stone, Clay, Glass	92.4	37.9	3,800	172.5	71.1	5,000	337.1	161.2	6,500	614.0	361.1	8,000
Primary Metals	118.8	53.6	4,100	518.6	216.7	7,300	885.3	392.1	8,700	1,408.5	699.8	9,900
Other Non-Durable Mfgrs.	168.7	92.0	15,100	344.3	187.6	19,700	740.8	468.6	25,200	1,485.6	1,555.8	30,900
Other Durable Mfgrs.	1,816.9	959.6	86,200	5,460.7	2,408.6	175,700	18,707.1	7,707.4	380,700	58.086.5	24,349.1	787.400
Transportation	615.6	461.1	40,200	1,192.8	894.6	36,200	2,422.7	1,990.8	29,700	4,585.6	4,373.5	23,300
Wholesale & Retail Trade	1,250.3	1,011.3	140,000	2,269.4	1,835.4	202,600	4,267.4	4,006.3	292,300	7,477.7	8,634.1	402,400
Services	1,149.5	842.2	144,000	2,185.9	1,604.5	230,100	4,356.0	3,711.8	388,800	8,088.8	8,477.0	627,300
Construction	673.8	277.0	41,200	1,359.7	558.8	54,500	2,869.9	1,395.9	70,500	5,644.7	3,442.6	87,200
Government	---	734.0	115,800	---	1,565.1	178,100	---	4,140.9	275,100	---	10,816.5	405,800
Consumption	---	600.8	---	---	790.8	---	---	1,191.6	---	---	1,773.0	---
Total	$7,869.4	$5,830.4	662.600	$16,710.7	$11,358.4	973,100	$39,961.8	$27,435.6	1,535,400	$96,010.2	$68,247.5	2,434,500

[1] Output is equivalent to sales, except for those industries where "margin" entries are used. "Margin" represents "mark-up" costs as in case wholesale retail trade.

[2] Value added: A firm's sales less the purchase of goods and services from other times. It is equivalent to the firm's contribution to gross regional product.

[3] Data in parenthesis is new data made available after the input-output study was completed.

Note: Figures may not add to totals due to rounding.
Source: *Appendix IV, Economic Environment.*

Future declines in the amount of farmland will be associated with urban-population growth and industrial expansion. Farming is expected to have its greatest decline in the Central Division as land is converted to more intensive use. The Northern Division is expected to contain the major share of farmland.

The total value of crop and livestock production is projected to increase from $128 million in 1963 to $165 million in 1980 and to $274 million by 2020.

In terms of percentages, the Northern Division is projected to show the largest increase in economic activity through 1980. Aluminum, petroleum refining, and education industries are expected to lead the way, especially in the Nooksack and Skagit Basins. The pulp and paper industry and the wood products industry also are expected. As most of these industries require water access, development of additional deep-water port facilities is expected. Recreation and tourism are expected to provide economic stimuli to the San Juan and Whidbey-Camano Islands.

The present economic upsurge in the Central Division is expected to continue, with the big growth "industries" in the Cedar-Green, Snohomish, and Puyallup Basins, being transportation equipment, construction, machinery, trade, finance, insurance, real estate, and services. However, noticeable declines in lumber and wood products economic activity is expected.

In the Western Division the forest products industries, particularly pulp and paper are expected to be high growth industries. In both areas, West Sound Basins and the Elwha-Dungeness Basin, tourism and recreation will continue to expand.

Future population and economic growth is expected to be the greatest in and adjacent to the existing urban centers with the basins. The greatest population changes are projected to occur in the Snohomish, Cedar-Green, and Puyallup River Basins with the growth spilling over from the Cedar-Green into the adjacent Snohomish and Puyallup Basins.

PROJECTED LAND USE

Future land use in the Puget Sound Area has been projected on the basis of five major land use categories. Alternative projections for cropland, rangeland, forest land, rural nonagricultural land and intensive or built-up lands were made, utilizing different population densities and other spatial distribution factors. The following alternatives were considered:

Pattern A.—Increase of population density to an average of 6.7 persons per acre in urban areas in 2020.

Pattern B.—Increase of population density to an average of 8.7 persons per acre in urban areas in 2020.

Pattern C_1—Increase of population density to an average of 6.7 persons per acre in 2020 in urban areas with cross-Sound bridges.

Pattern C_2—Increase of population density to an average of 9.9 persons per acre in 2020 in urban areas with cross-Sound bridges.

Each of the above alternatives imposes a different intensive land use requirement particularly for the basins within the Central Division. Generally, there are adequate lands for all uses, yet the compatibility of uses requires good planning and adequate developmental control. Intensive land uses will continue to expand outward from the various urban and community centers and will continue to infringe on existing agriculture and forest lands. Selective processes for the development of intensive uses must be more critical than they have in the past if urban development is to be properly located, and not to the detriment of the other major uses. Recreational and industrial uses must be dealt with on an equal planning basis, especially those requiring waterfront locations.

Land use pattern C_2 was adopted for this appendix as the most reasonable means of satisfying the Area's land use requirements. The development of cross-Sound bridges expands the current development pattern into the Kitsap Peninsula and island areas and conforms with current State transportation concepts. Additional details concerning this and the other land use patterns are in Appendix V, Water-Related Land Resources. A summary of intensive land use is given in Table 2-10 and a summary of projected land use is given in Table 2-11. The C_2 generalized land use pattern is shown in Figure 2-4.

TABLE 2-10. Intensive land use development in the year 2020, land use pattern C_2

Basins	Present Acres[1]	Present Density	2020 Acres[1]	2020 Density[2]	Acres of Land Displaced by Intensive use by Type: Forest	Rural Non-Farm	Crop land	Rangeland	Totals	Population 2020[1] (in 000's)
Nooksack	20,900	3.6	29,800	5.7	5,000	600	3,300	0	8,900	168.7
Skagit-Samish	18,800	2.8	23,600	5.0	1,600	300	2,800	100	4,600	118.2
Stillaguamish	6,700	2.4	12,700	6.1	4,200	600	900	300	6,000	77.8
Snohomish	36,300	4.9	84,000	9.1	20,800	18,900	8,000	0	47,700	761.4[3]
Cedar-Green	166,400	5.85	222,900	16.2	25,300	13,100	17,600	500	56,500	3,619.9[3]
Puyallup	97,400	3.33	138,200	8.0	17,300	19,800	3,200	500	40,800	1,107.5[3]
Nisqually-Deschutes	19,900	3.0	23,500	6.2	1,000	2,200	200	200	3,600	146.5
West Sound	42,200	2.90	100,300	6.3	25,900	27,900	4,000	300	58,100	632.7[3]
Elwha-Dungeness	5,900	3.3	10,800	5.2	2,800	900	900	300	4,900	56.6
Whidbey-Camano	11,000	1.8	43,000	2.7	20,000	9,500	2,000	500	32,000	115.0[3]
San Juan	2,800	0.94	3,600	1.4	100	700	0	0	800	5.1
TOTAL	428,300	4.35	692,400	9.9	124,000	94,500	42,900	2,700	264,100	6,809.4

[1] Figures rounded to the nearest hundred.

[2] Persons per intensive land use acre.

[3] Population projections adjusted to meet a population shift with the advent of bridges being contructed between the mainland and the peninsula and between Whidbey Island and the mainland.

Source: Appendix V, Water-Related Land Resources.

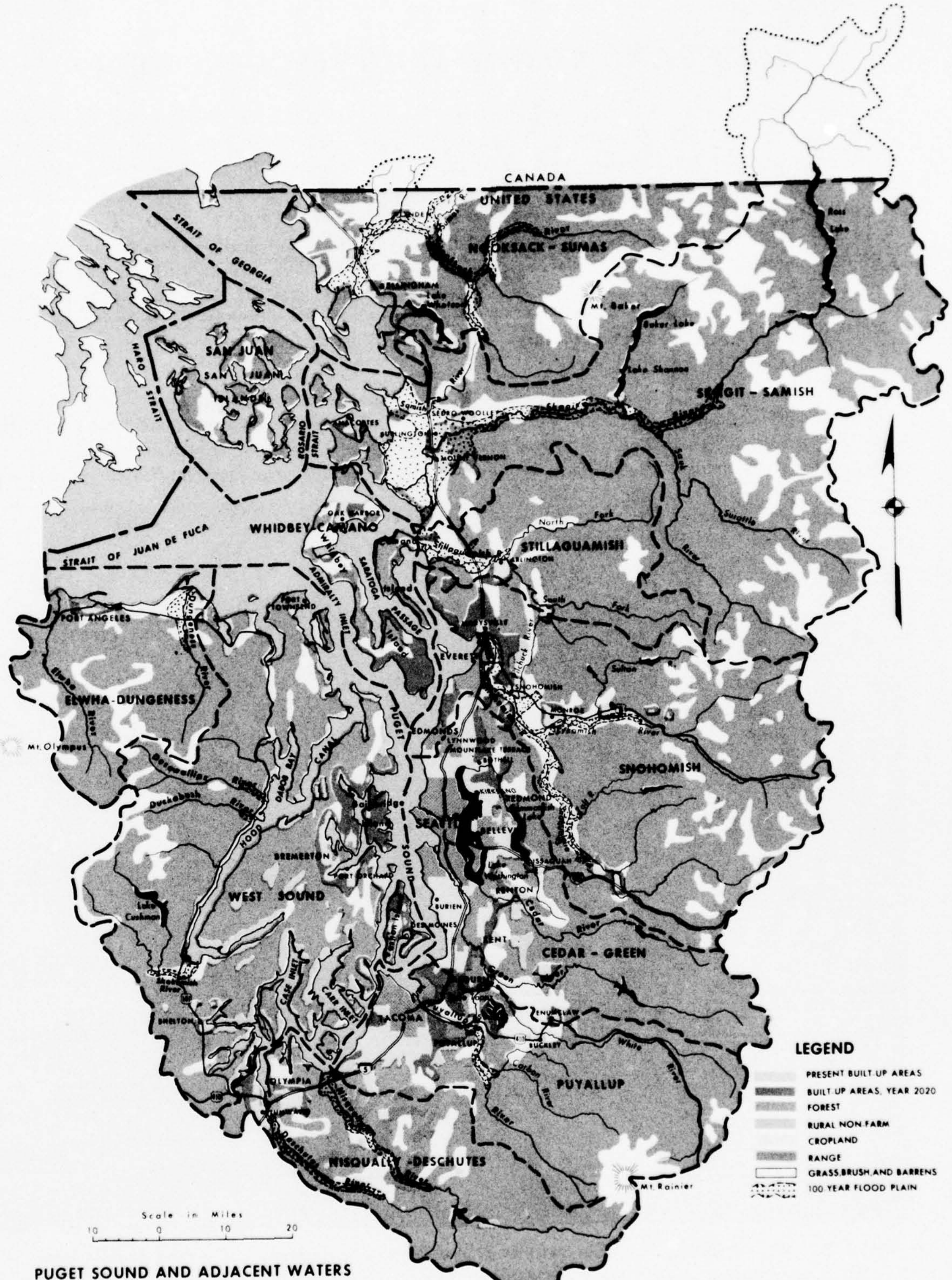
TABLE 2-11. Projected land use in the Puget Sound Area usage 2020 land use pattern C_2 (acres)[2]

Basin	Cropland	Rangeland	Forest Land[1]	Rural non-Agricultural Land	Intensive or Built-up Land	Fresh Water	Totals
Nooksack-Sumas	134,200	11,600	604,600	12,100	29,800	12,100	804,400
Skagit-Samish	97,700	19,700	1,751,800	19,800	23,600	35,400	1,948,000
Stillaguamish	33,600	700	381,300	5,300	12,700	4,700	438,300
Whidbey-Camano	21,000	2,000	64,100	2,900	43,000	700	133,700
Snohomish	63,800	2,400	1,033,900	10,400	84,000	23,900	1,218,400
Cedar-Green	35,800	2,900	421,400	21,200	222,900	38,800	743,000
Puyallup	33,700	5,200	576,000	5,900	138,200	11,300	770,300
Nisqually-Deschutes	45,300	43,300	505,800	17,700	23,500	10,100	645,700
West Sound	42,200	4,800	1,097,800	36,300	100,300	12,600	1,294,000
Elwha-Dungeness	22,800	2,100	406,700	4,200	10,800	1,800	448,500
San Juan	18,600	9,100	71,800	8,400	3,600	1,000	112,500
Total	548,600	103,800	6,915,200	144,400	692,400	152,400	8,556,800

[1] Figures include open and barren lands normally associated with forest areas.

[2] Figures rounded to the nearest hundred.

Source: Appendix V, Water-Related Land Resources.



PUGET SOUND AND ADJACENT WATERS
STUDY AREA

FIGURE 2-4.

Generalized Land Use
Alternative C2 –2020

WATER AND RELATED LAND RESOURCE NEEDS

The single-purpose needs were developed in Appendices V through XIV. This section summarizes the results of the studies for the Area showing needs projected for each feature at the various time levels. The present status of each feature is also summarized to provide a brief introduction to the functional concept and describe current resource use.

MUNICIPAL AND INDUSTRIAL WATER SUPPLY

General

Municipal and industrial water is supplied through diversion and distribution of surface waters or through development of ground water by numerous separate entities. Many of the industrial water supplies are provided by adjacent municipal systems. Some industries obtain water from independent surface or ground water sources as do many smaller communities and districts.

Surface waters are the primary source of supply for major urban centers. Ground water sources in addition to generally supplying outlying areas, also provide needed quantities during periods of turbidity in surface water sources.

Present and Future Needs

The future water needs are based on projected urban and industrial growth demands within each basin. Certain areas have insufficient ground water

PHOTO 2-7. City of Seattle municipal and industrial water supply reservoir, South Fork of Tolt River. The Tolt River is one of two surface water sources that the Seattle Water Department uses to supply approximately 120 million gallons per day to its service area. The other source is the Cedar River which the city has used since before 1900. Seattle Water Department Photo

supplies and other areas inadequate distribution and transmission facilities to meet private, municipal and industrial growth demands. Consolidation of servicing groups, updating of systems, development of new storage and regional distribution systems, and use of water treatment plants would be desirable.

The total Puget Sound Area municipal, industrial, and rural-individual water use for 1965 was estimated to average about 660 mgd, or some 738,000 acre-feet per year. Projected annual water needs for 1980, 2000, and 2020 are estimated to be 1,278; 2,023; and 3,159 mgd, respectively. The projected needs are tabulated, by individual basins, in Table 2-12.

The design of new, or expansion of existing distribution facilities to meet the projected average annual needs should incorporate the increased delivery capacities necessary to meet desired State ratings for health, fire protection and other peak demands.

A detailed discussion of municipal and industrial water supply is contained in Appendix VI, Municipal and Industrial Water Supply.

TABLE 2-12. Municipal and industrial water supply, average annual present use and projected needs, Puget Sound Area

Basin	1965 Use		1980		2000		2020	
	MGD	1000 Ac.Ft.	MGD	1000 Ac.Ft.	MGD	1000 Ac.Ft.	MGD	1000 Ac.Ft.
Nooksack-Sumas	73	82	156	175	212	237	293	328
Skagit-Samish	28	31	49	55	77	87	116	130
Stillaguamish	2	2	5	5	9	10	17	19
Snohomish	165	185	266	298	419	470	540	605
Cedar-Green	165	185	354	396	584	654	1,122	1,257
Puyallup	100	112	186	208	329	368	547	613
Nisqually-Deschutes	8	9	16	18	25	27	41	46
West Sound	49	55	93	104	139	155	182	204
Elwha-Dungeness	64	72	140	156	209	235	271	303
San Juan Islands	0.6	0.7	0.6	0.7	0.8	0.9	1.2	1.3
Whidbey-Camano Is.	4	4	12	13	19	22	29	33
Totals-Area	658.6	737.7	1,277.6	1,438.7	2,022.8	2,265.9	3,159.2	3,539.3

Source: Appendix VI, Municipal and Industrial Water Supply.

IRRIGATION

General

Since 1945, irrigation in the Puget Sound Area has shown marked growth. Land classification surveys from 1963 to 1966 indicated there were about 91,700 acres irrigated in the Area, as compared to 6,100 in 1919, and 10,300 in 1945.

The relatively uniform marine climate of the Puget Sound Area is suitable for growth of a variety of crops. Due to the moist climate, irrigation is primarily used to prevent crop failure and to maintain plant growth rather than to produce optimum yields.

Irrigated lands are generally in scattered small areas interspersed with larger areas of non-irrigated land. The suitability of irrigation is determined by soil characteristics, drainage, availability of water, and the type of system desired by the farm operator. There are abundant ground water and surface water sources in the Puget Sound Area, but combining all of the factors involved there has not been widespread development of large tracts for irrigation. Most of the lands presently irrigated have been developed through private means.

Present and Future Needs

Arable lands in the Puget Sound Area total 516,000 acres, of which 91,700 are presently irrigated and 424,300 are potentially irrigable. Most of the potentially irrigable lands are located on the flood plains of the rivers which flow into Puget Sound and on the intermediate terraces and upland glacial hills

along the river valleys. Irrigated cropland needed in 2020, projected on the basis of full development of land for crops is 396,000 acres. However, the encroachment of the urban and suburban population and industrial sector onto the irrigable lands limit the number of acres which actually would be capable of sustaining economical irrigation in the year 2020. Projections based upon estimated needs for food and fiber, location and extent of potentially irrigable lands, and availability of adequate water supplies indicate that irrigated lands in the Puget Sound Area will amount to 138,100 acres in 1980, 185,600 acres in 2000 and 223,100 in 2020. The projected acreages to be irrigated are summarized for the Area in Table 2-13 and the corresponding irrigation water needs are shown in Table 2-14.

A complete discussion of irrigation is contained in Appendix VII, Irrigation.

PHOTO 2-8. Farming near Orting in the Puyallup River Basin where cucumber crop growth is enhanced by irrigation through use of sprinkler systems. Bureau of Reclamation Photo

TABLE 2-13. Present and projected irrigation, Puget Sound Area

Basin	Present (acres)	1980 (acres)	2000 (acres)	2020 (acres)
Nooksack-Sumas	38,400	58,400	78,400	78,400
Skagit-Samish	6,200	16,200	26,200	51,200
Stillaguamish	2,500	6,500	10,500	10,500
Whidbey-Camano Islands	2,700	2,700	2,700	2,700
Snohomish	12,800	14,800	18,700	20,000
Cedar-Green	2,600	1,800	900	1,100
Puyallup	3,700	6,200	11,200	13,700
Nisqually-Deschutes	5,600	7,800	12,800	20,800
West Sound	1,200	1,600	2,100	2,600
Elwha-Dungeness	15,900	22,000	22,000	22,000
San Juan Islands	100	100	100	100
Puget Sound Area	91,700	138,100	185,600	223,100

Source: Appendix VII, *Irrigation.*

TABLE 2-14. Present and projected irrigation needs, Puget Sound Area

Basin	Present (1000 A.F.)	1980 (1000 A.F.)	2000 (1000 A.F.)	2020 (1000 A.F.)
Nooksack-Sumas	73.0	111.0	149.0	149.0
Skagit-Samish	12.0	31.1	50.3	98.3
Stillaguamish	4.8	12.5	20.2	20.2
Whidbey-Camano Islands	7.4	7.4	7.4	7.4
Snohomish	24.5	28.2	35.7	38.2
Cedar-Green	5.6	3.9	1.9	2.4
Puyallup	8.8	14.7	26.5	32.5
Nisqually-Deschutes	13.3	18.5	30.4	49.3
West Sound	3.1	4.1	5.4	6.6
Elwha-Dungeness	75.0	104.0	104.0	104.0
San Juan Islands	--	--	--	--
Puget Sound Area Total	227.5	335.4	430.8	507.9

Source: Appendix VII, Irrigation.

WATER QUALITY CONTROL

General

Water quality decline has occurred in a number of lower valley surface waters due to changes in land use and development and inadequately treated municipal and industrial waste discharges, especially in developed estuarial areas.

Wastes causing the degradation of water quality are contributed by municipalities, industries, agriculture, navigation, and recreation. An estimated 90 percent of wastes generated near marine waters in 1968 were untreated industrial wastes discharged from industrial sources; municipal wastes are treated before discharge. Implementation of the present marine waters (interstate) quality standards will reduce the untreated industrial wastes discharged.

Wastes discharged to fresh waters are receiving varying degrees of treatment. An estimated 34 percent of these are industrial wastes, discharged untreated to streams. More than three-fourths of the wastes generated in the Puget Sound Area are discharged into the Puyallup, Stillaguamish, Cedar-Green, and Skagit Basins and to related marine waters.

Present and Future Needs

State-Federal water quality standards provide the baseline from which present and future needs for water quality control are determined. Table 2-15 summarizes water quality standards for marine waters adopted by the State of Washington under the Water Quality Act of 1965 and adopted standards for fresh waters and lakes.

Wastes requiring treatment in the Puget Sound Area are projected to amount to 18,524,000 population equivalents in 1980; 23,587,000 population equivalents in 2000; and 28,943,000 population equivalents in 2020. Projected raw wasteloadings by time and basin are shown in Table 2-16.

Minimum streamflows required to assimilate treated wastes are given in Table 2-17.

The success of water quality control measures depends upon (1) adequate collection, treatment and dispersal facilities for wastes discharged into marine waters and, (2) secondary treatment, where effluents are discharged into streams, and (3) advanced (or tertiary) treatment where necessary to preserve water quality in lakes and impoundments or headwater areas. All activities which discharge wastes into the waters or affect water quality must provide all known available and reasonal methods of treatment and control. The separation of storm and sanitary sewers and adequate operation becomes increasingly important in reaching water quality goals. Sanitation requirements for pleasure boats and moorages are also important in achieving compliance with standards. Areas having high priority for waste collection and treatment facilities are located in the major urban-industrial complexes of Bellingham, Everett, Seattle and Tacoma. Sewage drainage basin plans are required.

A complete discussion of water quality is contained in Appendix XIII, Water Quality Control.

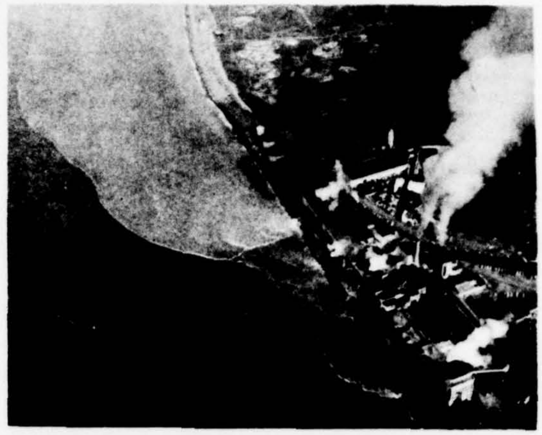


PHOTO 2-9. Industrial waste pollution along Puget Sound shoreline. Most industries are beginning to comply with Federal-State water quality standards which will eliminate major sources of pollution in the Puget Sound Area. Federal Water Pollution Control Administration Photo

TABLE 2-15. Water quality classifications and criteria, Puget Sound Area

Water Quality Standards	Class AA Extraordinary		Class A Excellent		Class B Good		Class C Fair	
	Fresh	Marine	Fresh	Marine	Fresh	Marine	Fresh	Marine
Coliform	50 MPN	70 MPN	240 MPN	70 MPN	1,000 MPN	1,000 MPN	1,000 MPN	1,000 MPN
Dissolved Oxygen	9.5 mg/1	7.0 mg/1	8.0 mg/1	6.0 mg/1	6.5 mg/1	5.0 mg/1	5.0 mg/1	4.0 mg/1
Temperature	60°F	55°F	65°F	61°F	70°F	66°F	75°F	72°F
pH	6.5-8.5	7.8-8.5	6.5-8.5	7.8-8.5	6.5-8.5	7.8-8.5	6.0-9.0	7.0-9.0
Turbidity	5 JTU	5 JTU	5 JTU	5 JTU	10 JTU	10 JTU	10 JTU	10 JTU
Toxicity	Shall be below those of public health significance, or which may cause acute or chronic toxic conditions to the aquatic biota, or which may adversely affect any water use.							
Aesthetic Values	Shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste.							

Source: Appendix XIII, Water Quality Control.

TABLE 2-16. Water quality control, projected before treatment raw wastes generated, Puget Sound Area (1000 population equivalents)

Basin	1965	1980	2000	2020
Nooksack-Sumas	2,031	3,102	3,624	4,087
Skagit-Samish	1,048	1,881	2,352	2,063
Stillaguamish	349	530	1,057	1,937
Whidbey-Camano Islands	24	89	141	186
Snohomish	7,169	5,886	6,079	6,057
Cedar-Green	1,348	2,359	3,986	6,658
Puyallup	839	1,226	2,173	3,182
Nisqually-Deschutes	139	189	338	584
West Sound	236	570	957	1,334
Elwha-Dungenesss	3,264	2,682	2,857	2,813
San Juan Islands	11	17	24	43
Puget Sound Area Total	16,458	18,524	23,587	28,943

Source: Appendix XIII, Water Quality Control.

TABLE 2-17. Minimum flow requirements, cfs, Puget Sound Area[1]

River and Location	1980	2000	2020
Nooksack, Lynden	180	350	725
Skagit, Mount Vernon	240	435	650
Stillaguamish, Stanwood	140	270	415
Snoqualmie, North Bend-Snoqualmie	10	20	25
Skykomish, Monroe	150	285	335
Snohomish, Snohomish	400	750	890
Puyallup, Puyallup	105	245	270
White, Puyallup	45	120	135
Puyallup, Tacoma	140	210	240

[1] Minimum flow estimates for West Sound, Elwha-Dungeness, Whidbey-Camano, San Juan, Cedar-Green and Nisqually-Deschutes Basins have not been developed.

Source: Appendix XIII, Water Quality Control.

NAVIGATION

General

The navigation resources of the Puget Sound Area, combining deep water easily accessible from the Pacific Ocean with sheltered waterways is a significant heritage. The maintenance of this resource requires cooperative planning on a continuous basis to ensure that the needs for commercial developments are met in a manner which protects the unique environment. The navigation use of the Puget Sound Area has been one of the several reasons for its rapid economic growth. From small lumber ports, seven major ports and a number of minor ports now serve the Area. The controlling depth at most harbor entrances is practically unlimited while at waterways and at berths alongside docks, the controlling depth varies from 25 to 70 feet. The Puget Sound Area ports are among the few natural harbors of the world which can handle "super bulk carriers," such as the "Manhattan" which has a draft of 51 feet fully loaded.

Most commercial navigation occurs on Puget Sound and adjacent marine waters with port facilities located along the shoreline of natural harbors. However, extensive use has been made of portions of river estuaries in the Snohomish and Cedar-Green Basins where channels have been dredged 7 and 5 miles, respectively, above the mouth of the Snohomish and Duwamish Rivers.

There are 32 active port districts in the Puget Sound Area, with the major ports located at: Seattle, Tacoma, Olympia, Bellingham, Port Angeles, Port Townsend, Everett, and Anacortes. A full range of facilities required to handle both bulk and general cargo efficiently, including containerization facilities and back-up areas are available. Total foreign and domestic coastwise and domestic internal waterborne commerce of the Puget Sound Area has increased from 31 million tons in 1952 to almost 42 million tons in 1966. The average annual rate of growth during this period has been about 2.5 percent. In 1964, 48,000 persons were employed in work related to waterborne commerce, and the direct value of related goods and services are estimated to be 1.1 billion dollars.

There are 22 federally authorized river and harbor projects in the Puget Sound Area, providing for construction of channels and breakwaters, annual maintenance dredging, and snagging and clearing of debris.

The waterfront terminal facilities in the Puget Sound Area serve an industrial complex which depends on waterborne commerce to enhance its competitive market position. Water transport-oriented industries had in use approximately 5,200 acres of land in 1963 while approximately 2,300 acres of land were used for terminal facilities.

Many of the ports provide small boat moorage facilities for recreation boating and accommodations for commercial fishing fleets. The registered pleasure boat ownership was about 62,000 in 1966, creating heavy demands on small boat facilities. A survey in 1966 of a representative sample of registered pleasure boat owners revealed a significant need for additional moorages above the 16,000 public rental moorages provided in that year. The Area has one of the highest per capita participation rates in pleasure boating of any major population center of the Nation.

Present and Future Needs

Significant growth in foreign and domestic coastwise and domestic internal commerce is projected over the 50-year study period with a total tonnage forecasted to rise from 42 million tons in 1966 to nearly 252 million tons by 2020. Additional lands will be required for terminal facilities to service these projected tonnages, as well as meeting the needs of water transport-oriented industry. The future land needs have been projected at 17,130 acres by 1980; 29,010 acres by 2000; and about 41,500 acres by the year 2020. Harbor and channel deepening projects would be required to insure that the world fleet with a growing trend to deeper drafts can be served in the waterways and berths of the Area. Channel depths of over 100 feet would be needed in some locations. Pleasure boating wet moorage demand is forecast at 43,790 moorages in 1980; 79,879 moorages in 2000; and 143,440 moorages by 2020. A large number of breakwater-protected marinas would be required to accommodate these demands. Table 2-18 summarizes the navigation needs for the Area.

Increased efficiency in cargo handling and land use would be necessary in order for the Area ports to remain competitive. Greater cooperation among ports and centralized planning are indicated as means of achieving these efficiencies.

Planning of the land transportation network, including warehousing, consolidation, and distribution facilities for integration with waterborne transportation is needed to take advantage of such

PHOTO 2-10. Manhattan, a 51-foot draft bulk cargo vessel receiving grain from the Hanford Street terminal in Seattle. Port of Seattle Photo

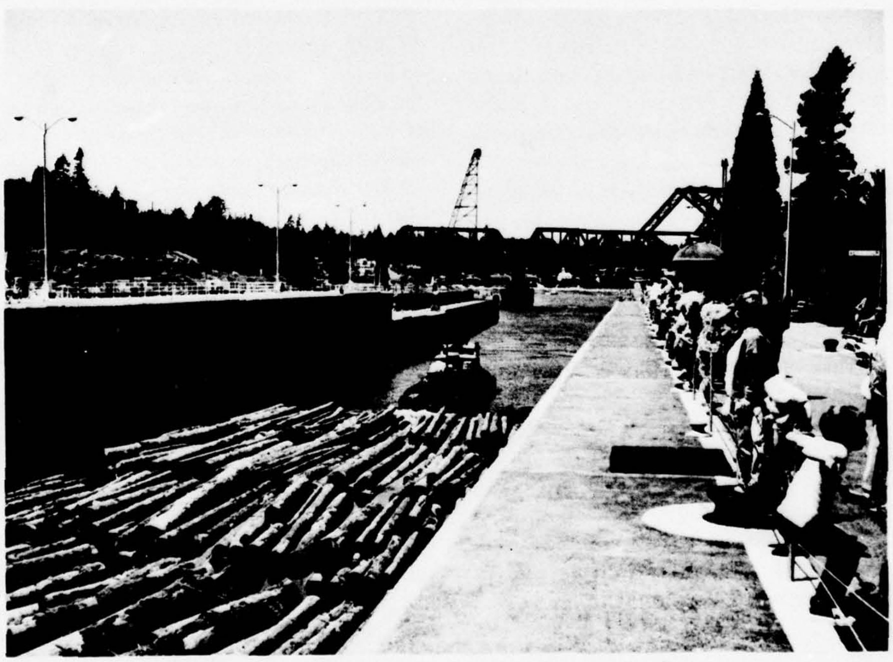


PHOTO 2-11. Tugboat towing log raft through Hiram M. Chittenden Locks where over 1 million visitors come each year to view the activity of the 50-year old locks. The locks, primarily used by pleasure craft, make possible deep draft ship movement through the heart of Seattle from Puget Sound to Lake Washington. Corps of Engineers Photo

TABLE 2-18. Gross navigation needs, Puget Sound Area

Basins	1980			2000			2020		
	Industrial & Terminal Lands (Acres)	Sm. Boat Harbors (Moorages	Waterborne Commerce (1,000 tons)	Industrial & Terminal Lands (acres)	Sm. Boat Harbors (Moorages)	Waterborne Commerce (1,000 Tons)	Industrial & Terminals Lands (Acres)	Sm. Boat Harbors (Moorages)	Waterborne Commerce (1,000 tons)
Nooksack-Sumas	2,040	990	4,700	3,480	1,620	12,700	5,870	2,700	30,100
Skagit-Samish	2,920	2,400	8,700	4,050	3,930	12,700	5,910	6,540	30,100
Stillaguamish	---	400	---	---[1]	770	---[2]	---[1]	1,500	---[2]
Whidbey-Camano	---[1]	3,770	---[2]	5,640	6,300	10,900	12,330	10,690	50,000
Snohomish	1,610	4,920	3,800	---	9,530	---	---	18,520	---
Cedar-Green	6,550	10,920	22,000	7,300	21,200	32,600	7,300	41,200	50,000
Puyallup	3,010	4,350	8,700	4,950	8,450	19,000	4,950	16,400	22,200
Nisqually-Deschutes	310	1,170	1,100	2,550	1,950	6,400	3,760	2,700	22,200
West Sound	---[1]	10,920	---[2]	---[1]	19,600	---[2]	---[1]	32,900	---[2]
Elwha-Dungeness	480	1,140	1 700	830	1,920	2,700	1,170	2,640	4,200
San Juan	---[1]	2,810	---[2]	---[1]	4,600	---[1]	---[1]	7,650	---[2]
Minor Ports	210	---	16,100	210	---	26,500	210	---	43,000
Puget Sound Total Area	17,130	43,790	66,800	29,010	79,870	123,500	41,500	143,440	251,900

[1] Industrial and terminal land needs in this basin are not forecasted as only minor development is anticipated

[2] Waterborne commerce projections for minor ports in this basin are included with total forecast for all minor ports in the Area.

innovations as containerization and unit transport. Environmental, social, and aesthetic considerations should be incorporated into navigation developments to avoid degradation of the valued marine environment. The requirement exists for the proper disposal of dredged materials in order to minimize or eliminate possible adverse effects on the environment. Public demand for recreation boating facilities has reached significant proportions in the Area. Accelerated development of small boat facilities would be required to meet this need and permit full utilization of the recreation boating advantages of Puget Sound and adjacent waters. A complete discussion of navigation is contained in Appendix VIII, Navigation.

POWER

General

Development of power resources in the Puget Sound Area is an important factor in the physical and economic growth of the Pacific Northwest. Policies, plans and programs for the conservation and beneficial use of the Area's water, land and mineral resources are all affected by power development. Low-cost power, abundant and widely available is an important factor in expanding industry and the general economy of the Area.

Importation of power began in the early 1940's and has increased until it now exceeds energy produced within the Area by more than 3 times. Presently there are seven gas turbine and thermal-electric plants in the Area with installed capacity totaling 202,310 kilowatts. There are two plants in the San Juan Islands with the remainder in the Cedar-Green and Puyallup Basins. In eight of the basins there are 22 hydroelectric plants with approximately 1.25 million kilowatts of installed hydroelectric capacity. The San Juan Islands, Whidbey-Camano Islands and Stillaguamish Basin have no hydropower developments.

The Puget Sound Area as a producer and consumer of electric power is expected to continue to be an integral part of the Pacific Northwest power economy. The Area is served on a coordinated basis

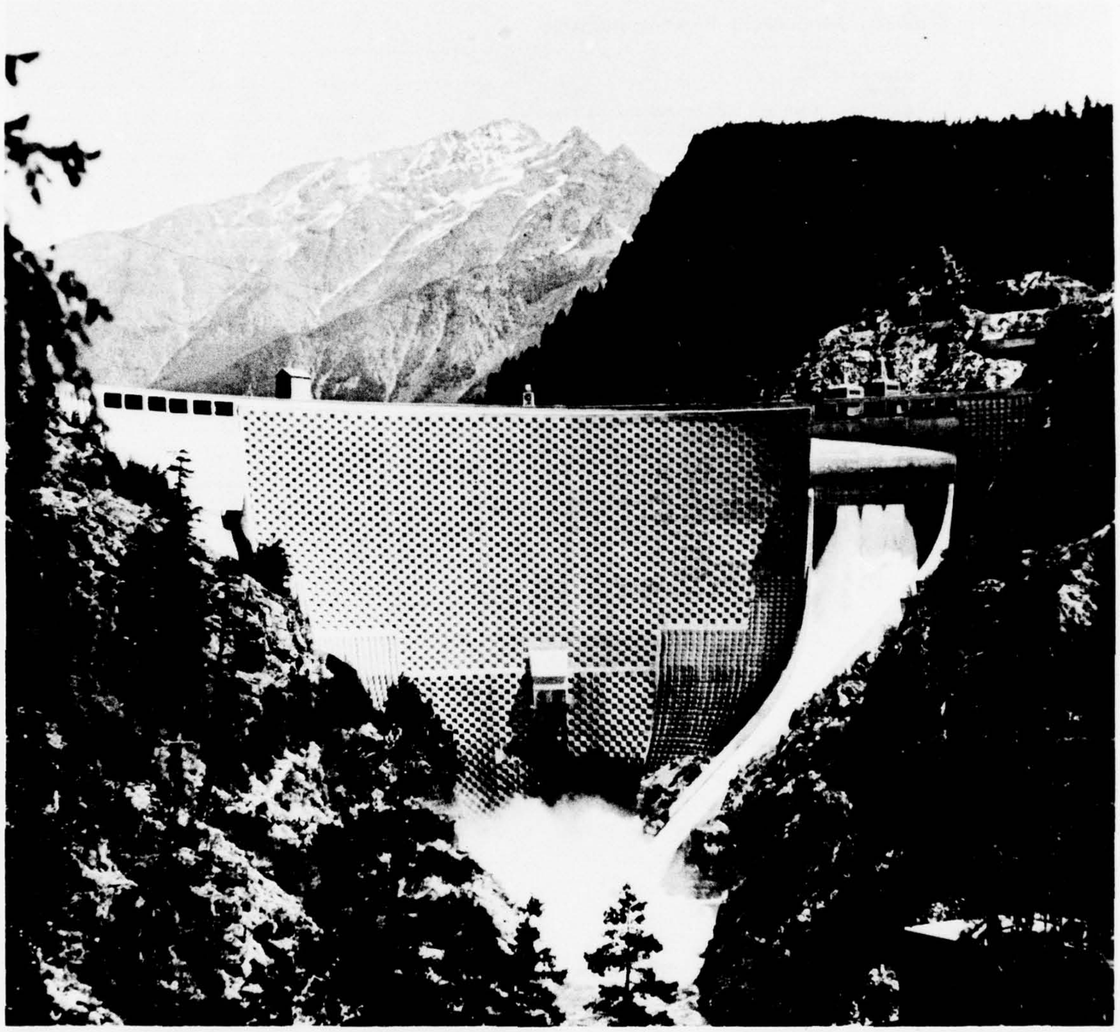


PHOTO 2-12. Seattle City Light's 540-foot Ross Dam during one of the few instances that water is going over the spillways. Ross Powerhouse generates up to 450,000 kw when the lake is full. Ross Lake has a total storage of 1,405,000 acre-feet and a usable storage of 1,023,000 acre-feet. The lake is kept at a reduced level from October 1 to March 15 each year to provide 120,000 acre-feet of storage for flood control. Seattle City Light Photo

through a number of interconnected generating and transmission systems for which the Federal regional transmission grid of the Bonneville Power Administration system provides the backbone. At present the Northwest is almost entirely hydro supplied, but a shift to a mixed thermal-hydro system is expected to be well underway by 1980, when the bulk of the economical hydro energy will have been developed. Economic hydro peaking capacity may be under development for a considerable period after that time. The Puget Sound Area is deficient in electric power resources and is expected to continue to be a large importer of electrical energy from the rest of the Pacific Northwest, principally the Columbia Basin.

The seasonal pattern of peak and energy loads within the Area is characterized by low summer loads and a winter peak. The winter peak is created mostly by electric heating. The Area is generally characterized by cool summers and as a result there is very little summer air conditioning load. Three municipally-owned, one Federally-owned, one private utility and two industrial firms produce and market electrical energy within the Area.

Present and Future Needs

With the projected population expansion and industrial development, the Area's electric power requirements are projected to increase from the 17,407 million kwh in 1965 to 400,000 million kwh in year 2020. This represents an overall annual rate of growth of 5.9 percent for the 55-year period to 2020. The projected electrical energy needs of the Puget Sound Area are shown in Table 2-19.

A complete discussion of power is contained in Appendix IX, Power.

FLOOD CONTROL

General

A total of 747,000 acres of land in the Puget Sound Area are subject to frequent flooding. Of this total 276,800 acres are subject to overbank flooding along the main-stems of major rivers. Flooding other than main-stem overbank flooding is discussed under Watershed Management.

Flooding by overbank flow of main-stem streams occurs on bottomlands in nine of the eleven Puget Sound Area Basins. The San Juan and Whidbey-Camano Islands have relatively small watersheds, and because of light rainfall, overbank flow flooding is a minor problem. Average annual flood damages are estimated at $7,122,000 for the Puget Sound Area. About $6,200,000 or 87 percent of the flood damages occur in the Skagit-Samish, Snohomish and Nooksack Basins.

Only portions of the Green and Puyallup River Basins have a level of flood protection to the standard required for urban areas. The lower Puyallup River Basin is protected against floods with recurrence intervals in excess of 100 years by Mud Mountain Dam and Reservoir and channel improvements. The Howard A. Hanson Dam and Reservoir has sufficient storage to provide in excess of 100-year control of Green River streamflow to a maximum of 12,000 cfs at Auburn.

Some agricultural lands are protected by levee systems. These levees are for the most part the result of efforts by local diking and drainage districts, constructed to prevent spring flooding. As a result, levee protected agricultural lands are still subject to winter flooding which occur on a frequency that varies from about once every two to eight years.

TABLE 2-19. Projected electric power requirements, Puget Sound Area

Year	Population (1000 People)	Per Capita Requirement (kwh)	Energy (Million kwh)	Loads[1] Average (1000 kw)	Loads[1] Peak (1000 kw)
1965	1,877	9,274	17,407	1,987	3,453
1980	2,727	17,700	48,300	5,530	9,730
2000	4,300	33,100	142,500	16,800	30,270
2020	6,809	58,700	400,000	47,700	89,400

[1] Includes reserve requirements.

Source: Appendix IX, Power.

PHOTO 2-13. Flooding of farmland in Snoqualmie River valley during November 1959 flood which was the result of intense winter storms. Damages occurred to cropland, buildings, equipment and transportation facilities. Corps of Engineers Photo

PHOTO 2-14. Flooding of town of Stanwood in Stillaguamish River Basin during November 1959 flood.

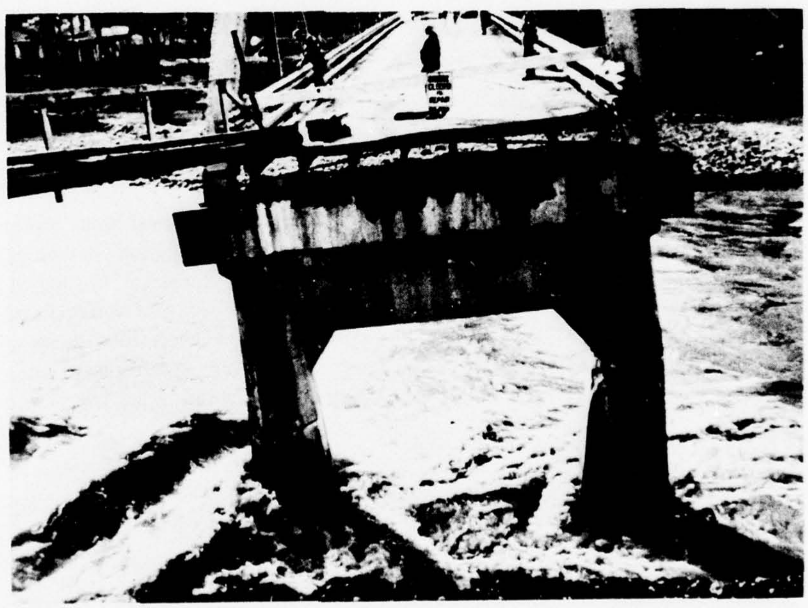


PHOTO 2-15. Flood damage to Mount Si Bridge, Middle Fork Snoqualmie River, November 1959 flood.

Optimum development of agricultural lands are thus restricted.

The heavy sediment load of many rivers in the Puget Sound Area adds to flooding problems. Rivers deposit sediment where the stream gradient flattens from the steep mountainous area to the flat flood plain. The continued deposition of sediment adds to overbank flooding conditions by reducing channel carrying capacity. As a result the upper reaches of the flood plains are subject to frequent changes in river channel location and direction. Bank erosion and loss of valuable farmlands are typical occurrences.

Present and Future Needs

The degree of flood protection should be compatible with the present and projected future use of the flood plain lands. The objectives of flood protection established for this study vary according to the type and intensity of existing and anticipated developments. The objective for urban and industrial lands is at least a 100-year level of protection; for prime agricultural lands with a high density of farm buildings and residences a 50-year level of protection; for other agricultural lands a 25-year level of protection; and for recreation and related use lands 10-15 year protection.

Most of the flood plain lands along the principal rivers are in need of measures to prevent flood damages. These measures include a flood plain management program for each basin as well as necessary and justifiable structures. Without additional protection, damages would increase with more intensive agriculture, urban and suburban developments, expansion of transportation facilities and utilities and construction of other facilities such as fish hatcheries. The projected damages are summarized by basin in Table 2-20.

A complete discussion of flood control is contained in Appendix XII, Flood Control.

TABLE 2-20. Average annual flood damages present and future conditions at existing levels of protection and at 1966 prices (in thousands of dollars)

	Under Development Levels of			
	1966	1980	2000	2020
Nooksack-Sumas	853	1,210	1,970	3,350
Skagit-Samish	3,020	4,340	7,060	12,030
Stillaguamish	256	380	690	1,310
Snohomish	2,310	3,520	6,370	13,100
Cedar-Green	447	780	1,700	3,740
Puyallup	100	151	301	602
Nisqually-Deschutes	57	69	110	160
West Sound	51	68	100	158
Elwha-Dungeness	28	38	54	80
Total	$7,122	$10,556	$18,355	$34,530

Source: Appendix XII, Flood Control.

WATERSHED MANAGEMENT

General

Watershed management is concerned with the use and care of land, and with the management of surface runoff or that part of precipitation that becomes part of the ground water resource. When watershed areas are in good condition the runoff is generally gradual and the water of good quality. Many of the watersheds in the Puget Sound Area are in relatively good condition at present. However, the activities of man or natural disasters has caused disruption of the natural hydrologic cycle in some watersheds and lead to changes in many aspects of the natural environment.

Urban expansion, logging, roadbuilding, and agriculture, has increased the volume and intensity of surface runoff. The result has, in some areas, been a loss of soil stability, accelerated erosion, sedimentation, stream and lake pollution, swamping, and associated damages to property and to natural resources. These damages are widespread and cause injury and expense to the general public. In addition to a need for more care in the use of watersheds and corrective measures, many opportunities exist to enhance various elements of the environment through management of the water and related land resource for specific objectives.

PHOTO 2-16. Sediment and debris filled stream channel of Juanita Creek caused by suburban housing developments, resulting in loss of aesthetics and habitat suitable for fish and wildlife. Soil Conservation Photo

PHOTO 2-17. Eroded east bank of Snohomish River, located 4 miles south of town of Snohomish, in need of bank protection measures. Soil Conservation Service Photo

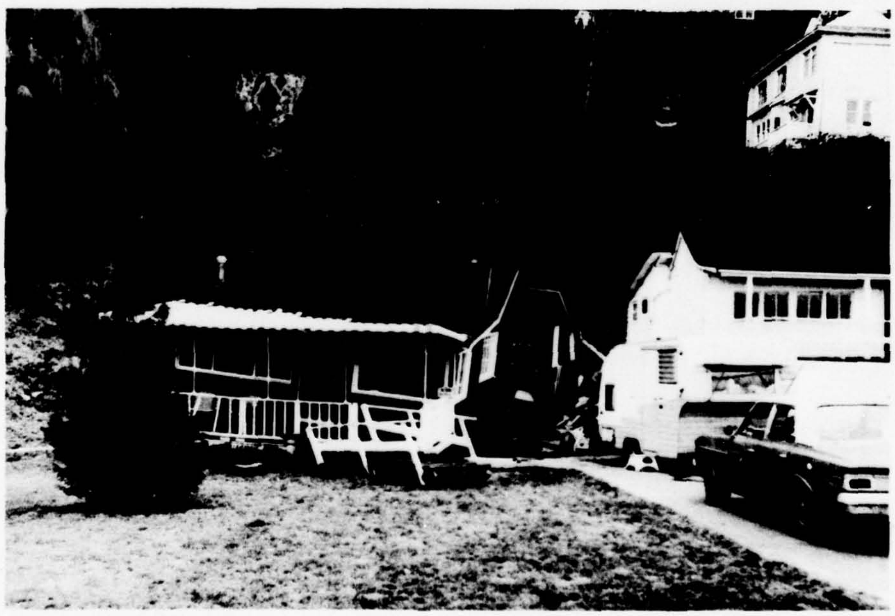


PHOTO 2-18. House, located in slide-prone area in West Seattle, wrecked by mud slide. Knowledge of unstable soils and proper land management are needed to prevent this problem. Soil Conservation Service Photo

Present and Future Needs

There are 747,000 acres in the Puget Sound Area subject to floodwater damage at least once in every 100 years. About 276,800 acres are subject to overbank flooding from the mainstem of major streams and require mainstem control, previously described under Flood Control. However, these same areas are also subject to flooding from excess precipitation or other causes in the absence of mainstem overflow. Consequently these 276,800 acres, as well as 470,200 acres of upstream and tributary area, require flood prevention, drainage, and other water management measures within the scope of watershed management activities. Care has been taken to prevent double counting of development needs. Irrigation development requirements, while a facet of watershed management, are presented under Irrigation.

Projections of population and economic growth indicate accelerating demands on the Area's land and water resources. Urban and industrial use would require intensive development of an additional 373,000 acres of land by the year 2020.[1] Production of food and fiber from the Area's forest and agricultural lands would be greatly increased at the same time these lands are receiving mounting pressure for other uses, particularly outdoor recreation.

These and other land use developments in the Puget Sound Area would require a greatly accelerated program of watershed management for the protection of land and water values. Currently the program is more than 50 percent deficient in meeting the optimum needs of the Area. In addition to making up the current deficit, future watershed management planning should be made an integral part of such development. Research and data collection are needed in the fields of hydraulic characteristics, sedimentation, beach erosion, channel erosion, and soil surveys.

Where watershed land is designated for a specific use; e.g., recreation, municipal and industrial water, or water quality control, management practices peculiar to that use would be needed. On lands which serve multiple uses, such as farming and recreation, forestry and recreation, forestry and water quality, and so on, management practices to prevent deterioration of the environment would be needed. For this category of practices, the needs would grow as population of the Area increased.

The upstream and tributary area subject to floodwater damage is approximately 25 percent forest and rangeland, 61 percent cropland, and 14 percent more intensively developed land. Damages are estimated at $8,822,000 annually. This is in addition to the overbank flood damage estimates presented in the section on Flood Control.

The area of forested land is not considered to require flood prevention or flood control measures under conditions of use in 1967, but would require such protection as use changes. Cropland should have protection from floodwater damage to enable higher yields. Intensively used land requires 100-year level of protection. Some croplands and other lands are comingled with transportation and other improvements and require intermediate levels of protection that should be determined by individual, detailed analysis.

Soil erosion reduces the value of the land and contributes to streambed sediment loads, channel deterioration, and sedimentation of reservoirs and estuaries. Likewise, the deposition of stream sediment in lower channel areas reduces the flood-carrying capacity of streams and increases overland flooding, stream channel braiding and bank erosion. Sediment also has adverse affects upon quality of water for human consumption and industrial use, and for fish and wildlife. Nearly all of the land in the Puget Sound Area periodically is subject to erosion. The combined areas of agricultural, forest, and urban land requiring continued protection and rehabilitation measures total 8,404,200 acres.

Streambank erosion and braiding conditions are heavy producers of channel sediment. Precise needs in this area are not known. However, about 1,000 miles of mainstem and tributary channel banks are estimated to need measures for rehabilitation and protection.

Forty-three percent of the lands covered by the soil survey in the Puget Sound Area are found to have drainage problems which affect their use for food and fiber production, urban development, and other purposes, including construction. Acreages requiring drainage improvement and other water management for agricultural and urban uses are shown by time periods in Table 2-21.

Beaches are the relatively unstable transition where the land mass and the tidal waters meet. Beaches in the Puget Sound Area are relatively

[1] See Table 2-1 and 2-23, Appendix XIV, Watershed Management.

TABLE 2-21. Principal watershed development needs, Puget Sound Area

Basin	1970 to 1980				1980 to 2000				2000 to 2020			
	Flood[1] Prevention	Watershed Protection & Rehabilitation	Water Management (agriculture)	Water Management (urban)	Flood[1] Prevention	Watershed Protection & Rehabilitation	Water Management (agriculture)	Water Management (urban)	Flood[1] Prevention	Watershed Protection & Rehabilitation	Water Management (agriculture)	Water Management (urban)
	1000 acres	1000 acres	1000 acres	1000 acres	1000 acres	1000 acres	1000 acres	1000 acres	1000 acres	1000 acres	1000 acres	1000 acres
Nooksack-Sumas	135.1	792.2	55.4	33.6	135.1	792.2	92.3	33.6	135.1	792.2	123.1	33.6
Skagit-Samish	155.4	1912.6	49.0	38.9	155.4	1912.6	81.7	38.9	155.4	1912.6	108.9	38.9
Stillaguamish	34.8	433.6	13.5	12.6	34.8	433.6	22.6	12.6	34.8	433.6	30.1	13.0
Whidbey-Camano	25.6	132.9	8.6	23.4	25.6	132.9	14.4	23.4	25.6	132.9	19.2	23.4
Snohomish	93.4	1194.6	25.7	65.7	93.4	1194.6	42.9	81.0	93.4	1194.6	57.2	130.1
Cedar-Green	63.9	704.1	10.6	264.9	63.9	704.1	17.8	317.3	63.9	704.1	23.7	433.7
Puyallup	66.2	759.0	12.0	123.2	66.2	759.0	19.9	123.6	66.2	759.0	26.6	198.5
Nisqually-Deschutes	68.4	635.6	5.3	39.8	68.4	635.6	9.0	39.8	68.4	635.6	11.9	39.8
West Sound	71.0	1281.4	17.1	106.4	71.0	1281.4	28.6	106.4	71.0	1281.4	38.1	106.4
Elwha-Dungeness	15.9	446.6	9.6	11.0	15.9	446.6	16.1	11.0	15.9	446.6	21.4	11.0
San Juan	17.3	111.6	9.9	11.9	17.3	111.6	16.4	11.9	17.3	111.6	21.9	11.9
Totals	747.0	8,404.2	216.7	731.4	747.0	8,404.2	361.7	799.5	747.0	8,404.2	482.1	1,040.3

[1] Needs include 276,800 acres discussed under "Flood Control," but do not include the main stem control measures discussed in that section. See text for further details.

Source: Appendix XIV, Watershed Management.

narrow except in the vicinity of major rivers and along certain coves and bays. In the Skagit and Nooksack Basins, among others, some tidal areas have been reclaimed by seawall dikes and used for farming. These dikes are subject to damage by wave action. A considerable portion of the wave-cut terrace along the eastern shore of the Puget Sound is occupied by railroad rights-of-way.

The Area has over 2,000 miles of marine shoreline, of which approximately 187 miles are considered to be in need of stabilization and/or rehabilitation. In some places the erosion is advancing at an average rate in excess of one foot per year. A study is required to fully evaluate needs for beach protective measures and for determining applicable means of beach erosion control. The estimated distribution of beach erosion is shown in Table 2-22.

The reader is referred to Appendix XIV, Watershed Management, for further details.

TABLE 2-22. Erosion reduction needs, Puget Sound Area

Basins	Streambank Erosion: Braiding (feet)	Streambank Erosion: Severe (feet)	Streambank Erosion: Moderate (feet)	Beach Erosion (miles)
Nooksack-Sumas	191,000	89,800	93,600	5
Skagit-Samish	24,400	89,200	61,800	20
Stillaguamish	8,000	245,500	77,000	5
Snohomish	44,000	98,000	92,000	12
Cedar-Green	---	143,750	124,950	35
Puyallup	77,000	54,750	72,700	5
Nisqually-Deschutes	14,350	60,650	66,750	--
West Sound	5,150	10,650	11,250	39
Whidbey-Camano Islands	---	---	---	31
San Juan Islands	---	---	---	20
Elwha-Dungeness	---	2,700	12,550	15
Total measures	363,900	795,000	612,600	187

Source: Appendix XIV, Watershed Management.

RECREATION

General

The water and related lands of the Puget Sound Area are nationally and internationally recognized for their recreational use and potential. The outstanding physical features of the Area include extensive mountain ranges and forests, streams, lakes, and marine waterways which provide opportunities for many diverse forms of outdoor recreation activities.

The total use of recreation resources in the Area was estimated to be 58 million recreation days in 1960 of which about 24 million recreation days were for water-related activities. Demands for water-related activities are expected to reach 172,200,000 recreation days by the year 2020 representing a six-fold increase over 1960.

Present and Future Needs

Competing land and water uses impair and restrict the public use of these resources for recreation. For example, residential developments, shoreline roads and railroads and private ownership of waterfront and tidal areas restrict the use of marine resources for public enjoyment. Increasing stretches of tideland and beach are being filled or dredged to accommodate residential and commercial uses. In several localized situations, pollution has reduced the value of water for recreational use.

The Area contains a wealth of outdoor resources and many of these resources are presently unusable or unavailable to the public and therefore, do not contribute to the supply of outdoor recreation opportunities. The current demand for water related opportunities exceeds the existing supply of outdoor recreation facilities. Over 60 percent of outdoor recreation use occurs during the summer, and more than one-half of this use takes place on weekends. During heavy use periods recreation areas are overcrowded, especially those within or near urban areas.

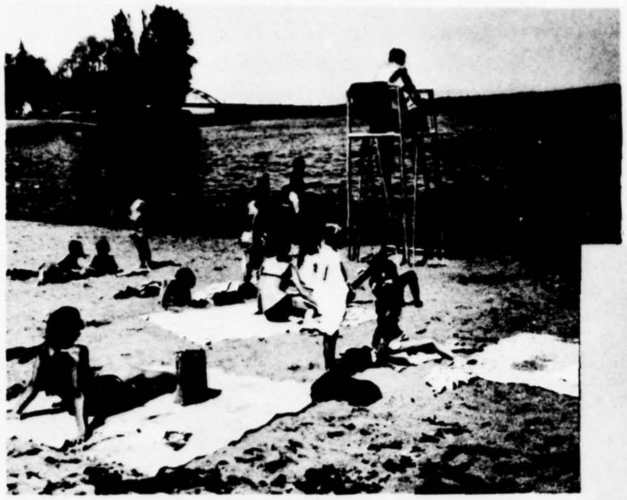


PHOTO 2-19. Lake Washington, with Interstate 90 floating bridge in background. Urban outdoor recreation opportunities are excellent in the Puget Sound Area with many fine parks and bathing beaches in and near urban centers. However, demand exceeds supply with substantial expansion and development of new facilities needed. Corps of Engineers Photo

PHOTO 2-20. Sailing on Puget Sound in waterways of San Juan Islands. Pleasure boating is one of the most favorite outdoor recreation activities of the Area with existing public rental moorages being less than required to satisfy boater demand. Washington State Department of Commerce and Economic Development Photo

PHOTO 2-21. Some of the 4,000 persons who crowd Bay Lake in the West Sound Basins on opening day of trout season. Scene is typical of most lowland lakes on opening day. Washington State Department of Game Photo

With the increasing concentration of population in metropolitan and suburban areas, the need to escape from man-made confines to outdoor recreation areas are expected to increase. About one-half of the future outdoor recreation demands and needs are anticipated to occur in and near the major metropolitan centers.

The projected water-related recreational needs are summarized in Table 2-23.

TABLE 2-23. Present and future water-related recreation needs, Puget Sound Area

Basin	1000 User-Days			
	1960	1980	2000	2020
Nooksack-Sumas	2,100	4,100	7,800	14,400
Skagit-Samish	2,200	4,300	8,300	15,200
Stillaguamish	830	1,600	3,000	5,500
Whidbey-Camano Island	1,500	3,000	5,800	10,800
Snohomish	3,600	7,200	15,000	26,000
Cedar-Green	4,700	9,400	18,100	33,600
Puyallup	2,500	5,000	9,700	18,000
Nisqually-Deschutes	2,100	4,200	8,000	14,900
West Sound	4,000	8,100	15,700	29,200
Elwha-Dungeness	650	1,300	2,500	4,600
Total for Area	24,180	48,200	92,900	172,200

Source: Appendix X, Recreation.

Only the water-oriented recreation needs were considered in this study. Such needs consist of swimming, boating, sailing, water-skiing, camping, picnicking, and hiking. Swimming is projected to be the most popular recreational activity followed closely by boating, camping, picnicking, and hiking.

Satisfaction of these demands would require land acquisition and facility developments interspersed throughout the Area, with emphasis on urban recreational development and salt water shoreline acquisition and development.

A complete discussion of recreation is contained in Appendix X, Recreation.

FISH AND WILDLIFE

General

The varied marine, forest and mountain environments in the Puget Sound Area supports a wide and abundant variety of fish, shellfish and wildlife. These resources are in close proximity to the metropolitan centers of the Area and offer a wide range of commercial and recreational opportunities that are unique.

In 1965, sport angler use was estimated to be in excess of 5,721,000 angler-days, of which approximately 41 percent involved anadromous fish, 56 percent resident fish, 1 percent marine fish exclusive of salmon, and 2 percent shellfish. This amount of angler use was valued at $25,086,300. The commercial catch for 1965 amounted to 44,252,000 pounds, with a total value to the fishermen of $6,345,400. An estimated 847,000 hunter-days were spent in wildlife use pursuits. Such use is conservatively valued at $4,235,000. The fish production capabilities of various Area waters are considered good to excellent.

Wildlife are a product of the land and vegetative cover. The type, or species, and number of animals or birds found in an area is dependent upon the quantity and quality of the habitat. The basic elements of habitat, food, cover and water vary in type, quantity and quality as a result of existing climatic conditions, soil, and topography. Each unit or area of habitat has a specific capacity to support wildlife. Wildlife cannot migrate to another area if a home territory is denuded of vegetation for some other use. The "other areas" are already supporting wildlife at the habitat carrying capacity. Human population demands for agricultural, urban, and industrial uses occur almost exclusively at low elevations, the area of highest productivity for wildlife. Consequently, human competition is direct and critical to wildlife survival.

Present and Future Needs

Future demand for hunting and fishing is expected to increase substantially due to population growth, rising personal income, increased leisure time, ease of transportation and mobility improved and reasonably priced equipment, and the continued assurance of access to the fish and wildlife resource.

The fish and wildlife needs projected in terms of user-days are shown in Table 2-24. In deriving the needs the assumption was made that present fishing and hunting success levels would be retained.

Numerous problems and conflicts resulting from population increases associated with industrial, urban, and suburban expansion would need to be resolved as these developments tend to reduce the

PHOTO 2-23. Typical scene on opening day of trout season. Trout are planted in most lakes and streams of the Area providing enjoyment to fishermen of all ages. Washington State Department of Game Photo

PHOTO 2-22. Hunter leaving marsh with bag of waterfowl. Excellent hunting opportunities are available in some river deltas although additional public access is needed. Bureau of Sport Fisheries and Wildlife Photo

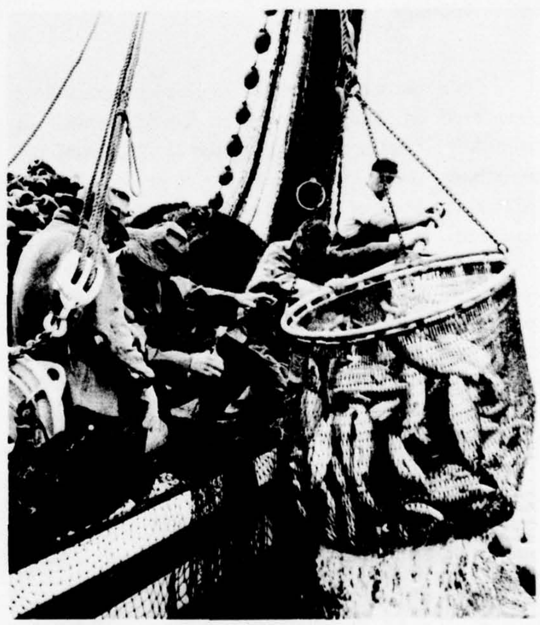


PHOTO 2-24. Sockeye salmon being bailed from net of purse seiner after successful set in Puget Sound. Approximately 250,000 sockeye salmon in 1969 returned to Cedar River via Lake Washington Ship Canal. Washington State Department of Fisheries Photo

natural production capacities of fresh and salt-water environments. The major problems which affect fish production are listed in Table 2-25. Some of these limitations occur naturally, while others result from man-made activities.

.Supplemental legislation is needed to protect and enhance fish and wildlife habitats. Public awareness, improved technology and management programs are essential to maintaining adequate levels of fish and wildlife under conditions of increased population. More information is available in Appendix XI, Fish and Wildlife.

TABLE 2-24. Summary of fish and wildlife needs, Puget Sound Area

	Units	1965	1980	2000	2020
Sport Fishing	1,000 User-Days	5,721	9,489	15,245	24,546
Hunting	1,000 User-Days	847	1,635	2,651	3,271
Commercial Fishing	1,000 Pounds	44,252	52,565	72,178	93,977

Source: Appendix XI, Fish and Wildlife.

TABLE 2-25. Major limiting factors on fish production in the Puget Sound Area[1]

	Limiting Factors[1]								Fish Life Affected			
Basin	Flooding	Low Summer Flows	Natural Barriers	Manmade Barriers	Erratic Streamflows	Unstable Streambed	Production Area Loss	Poor Water Quality	Anadromous Fish	Resident Fish	Marine Fish	Shellfish
Nooksack-Sumas	X	X	X		X	X	X	X	X	X	X	X
Skagit-Samish	X	X	X	X	X		X		X	X	X	X
Stillaguamish	X	X	X					X	X	X	X	
Whidbey-Camano		X							X	X		
Snohomish	X	X	X	X	X		X	X	X	X	X	X
Cedar-Green	X[2]	X		X			X	X	X	X	X	X
Puyallup	X	X		X	X	X	X	X	X	X	X	X
Nisqually-Deschutes	X[3]	X	X[3]	X[3]	X[3]		X		X	X		
West Sound	X	X	X			X	X	X	X	X	X	X
Elwha-Dungeness	X	X	X	X				X	X	X	X	X
San Juan		X							X	X		

[1] Further defined in each basin discussion.

[2] Cedar Basin only.

[3] Nisqually Basin only.

Source: Appendix XI, Fish and Wildlife.

COMPREHENSIVE PLAN

BASIS OF PLANNING

The methodology and criteria discussed previously were applied to the formulation of a Comprehensive Plan for the Puget Sound Area. The implementation of this planning process included consideration of needs and opportunities in each river basin. The results of individual basin planning have been reaggregated into a Comprehensive Plan for the entire Puget Sound Area.

Summary of Area Needs

Shown in Table 2-26 are water and related land resource needs by each river basin. These are net needs, or the projected output measure of water, land or other quantities that would require planning and investment in order to satisfy. In some cases, e.g., municipal and industrial water supply, the net needs are the difference between projected water use and existing use. For water quality the net needs equal the projected levels of raw wasteloading with adjustments for existing treatment. The needs for watershed management are shown as land areas which would require various forms of corrective or improvement measures during each time period. The derivation of net needs by water resource feature is contained in each basin discussion.

General Planning

A broad range of alternative measures for meeting the water and related land resource needs of the Puget Sound Area were viewed in the formulation process, with a combination of these measures found to be necessary to fully meet the needs. The following discussion summarizes the various alternatives and opportunities considered in formulation of the Comprehensive Plan.

The outputs from existing, under-construction, and pending-authorization projects were recognized and consideration was given to changing the operation of existing projects to gain greater net benefits.

Direct river pumping and treatment, desalinization, diversion, storage, increased ground water utilization, and improved water yield through various watershed management practices were considered as means for satisfying water supply needs of municipalities and industry. There are adequate flows within the river basins to satisfy the water supply requirements of major purveyors and other uses, provided these flows can be controlled and managed. There are numerous sites available for multiple-purpose storage in major river basins. Appendices III, Hydrology and Natural Environment, and XII, Flood Control, indicate existing and potential storage sites.

Ground water supplies appear to be adequate to meet much of the present and future needs of small and rural communities and provide supplemental supplies for the larger cities, although further investigations are required in order to accurately determine the amount of usable ground water resources. Desalinization of water from Puget Sound and adjacent waters is not considered to be economically competitive with other alternatives at this time. Consequently, diversion, storage, direct pumping and treatment of water from the larger streams and ground water use were viewed as the most feasible alternatives for satisfying future municipal and industrial requirements.

Surface and ground water supplies are adequate in most basins to satisfy irrigation and water supply needs through pumping. More efficient use of the water resources can in some basins provide opportunities for other competing uses as well as meeting the requirements for irrigation.

Water quality problems associated with organic wasteloadings exist in all the major rivers in the Area and in marine waters. However, with construction of collection and treatment facilities, the water quality standards set forth in the Implementation and Enforcement Plan for Interstate Waters, 1967, and Intrastate Waters, 1969, of the State of Washington, can be satisfied. Opportunities considered for satisfaction of water quality needs were sewage collection and treatment facilities, minimum streamflows for the assimilation of residual wastes after treatment, sewer outfall and dispersal facilities, sludge removal, and waste collection facilities on small boats used for pleasure purposes.

Navigation channels can be deepened in most basins to accommodate the growing vessel drafts. Land requirements for terminal and water transport-oriented industrial development can be met with retention and development of sites found in this study to be favorable for development. Lands suitable for terminal and/or water transport-oriented industry are located primarily along the eastern shoreline of Puget Sound in developed and undeveloped areas.

The Area has numerous sites that have a potential for hydroelectric power development as part of multiple-purpose storage projects, although only a few sites were specified in the Comprehensive Plan for development. A number of pumped storage sites exist that could be used to satisfy peaking power requirements in a long-range period. Nuclear power production being considered at sites within the Area would require further engineering, economic, and environmental impact studies before final decisions as to plant construction could be made. The planning for the Puget Sound Area recognized the potential in those basins where active consideration had been given to development of the nuclear power plants. However, the Plan neither sets forth the specific sites for nuclear power plants nor schedules their development.

Considerable opportunity exists in the Area for accomplishing future flood damage reduction by the implementation of flood plain management measures including zoning, floodproofing, and warning systems. However, such measures would not, significantly, reduce flood damages to existing developments. The construction of levees, channel improvements, stabilization and drainage facilities, small watershed projects and accompanying management practices are nonstorage measures which provide opportunities to accomplish desired flood control objectives. In only a few basins is there adequate storage capability to satisfy flood control objectives by this means alone. Other structural measures, including levees and diversion channels, are required in addition to management of land use to provide adequate flood protection and damage reduction.

The land resources within the Area are sufficient to meet the future needs of recreation development. Municipal watersheds, currently closed to public recreational use or allowing only restricted public access, are viewed as being potentially available for this purpose at such time as the need is commensurate with the associated costs of water treatment. These watersheds contain approximately 320,000 acres of land as compared to the total land area of 8,402,000 acres (approximately 4 percent of the total land is in municipal watershed). Many municipal water suppliers own all or a portion of their watersheds. Consequently, these property rights, as well as public health impacts of recreation activity on water quality, must be considered before the watersheds are made available for recreation use. In addition, the question of payment for expensive treatment facilities (required if the watersheds were opened) must be studied.

Ninety-seven sites along the Puget Sound shoreline are suitable for development as small boat harbors with the capability of accommodating over 115,000 wet moorages. Small boat harbor sites, inventoried in this study, are sufficient to meet public wet moorage development needs to the year 2020 in most basins, with some use of moorage opportunities in adjacent basins possible. In the more populace basins greater use of dry moorage may be required in the long-range period to satisfy total moorage needs than has been the case in the past or than has been indicated desirable by boaters.

The total land areas required in support of fish and wildlife enhancement projects are minimal relative to the total land within the Area. However, the retention of sufficient habitat for the maintenance of desired game populations is required. Further opportunities may be provided for satisfying future hunting needs by opening municipal watersheds to this activity.

The water related land resource needs were examined in terms of projected land use pattern C_2 (see Projected Land Use), which is based on the construction of a cross-Sound bridge and a bridge between the mainland and southern Whidbey Island by the year 2020. The land base needs of irrigation, navigation, electric power, recreation, fish and wildlife, forest production, cropland and rangeland were considered within this context.

SUMMARY OF COMPREHENSIVE PLAN

The Comprehensive Plan for the Puget Sound Area includes both programs and projects, categorized as early action or long-range depending upon the urgency of the needs to which they are responsive. The early action portion of the Plan provides for management and development of water and related land resources required to meet the Area's needs projected for the year 1980. The long-range portion of the Comprehensive Plan deals with programs and projects to be implemented after the year 1980 to meet foreseeable needs projected to the year 2020. The Plan is first discussed in general terms and summarized in tables, followed by a detailed description by features.

Planning was done with an overview of the Area's total needs and resources with each river basin

TABLE 2-26. Summary of needs, Puget Sound Area[1]

Feature / Units and Years	Nooksack-Sumas	Skagit-Samish	Stillaguamish	Whidbey-Camano Islands	Snohomish	Cedar-Green	Puyallup	Nisqually-Deschutes	West Sound	Elwha-Dungeness	San Juan Islands	Puget Sound Area
	BASINS											
M&I Water Supply MGD												
1980	83	21.3	2.3	7.9	102.1	188.3	85.7	8.5	43.8	75.5	0.0	618.4
2000	139	49.1	6.7	15.6	255.3	418.5	228.3	16.9	89.9	144.8	0.2	1,364.3
2020	220	88.5	14.4	25.5	375.9	957.1	446.9	33.5	132.2	207.0	0.6	2,502.6
1000 acre-feet												
1980	93	23.7	2.6	8.8	114.0	210.8	96.0	9.6	48.1	83.7	0.0	689.4
2000	156	56.1	7.5	17.4	285.7	468.8	257.2	18.8	99.7	162.8	0.2	1,530.2
2020	247	98.7	16.2	28.5	420.7	1,072.0	501.5	37.4	147.8	231.0	0.7	2,802.4
Irrigation Water 1000 acre-feet												
1980	38	19.1	7.7	--	12	0	5.9	5.2	1.0	29.1	--	118.0
2000	76	38.3	15.4	--	19	1	17.7	17.1	2.3	29.1	--	215.9
2020	76	86.3	15.4	--	22	2	23.7	36.0	3.5	29.1	--	294.0
Water Quality Control Waste 1000 PE												
1980	2,981	1,860	414	85	5,429	1,787	1,063	166	542	2,681	17	17,025
2000	3,503	2,331	941	136	5,722	3,414	2,013	315	929	2,856	24	22,184
2020	3,966	2,042	1,821	181	5,700	6,086	3,019	561	1,306	2,812	43	27,537
Navigation Commercial 1000 short tons												
1980	3,200	2,200	--	--	1,100	9,200	3,700	200	--	500	--	27,500[2]
2000	11,500	6,200	--	--	8,200	19,800	14,000	5,200	--	1,500	--	83,400[2]
2020	27,900	23,600	--	--	47,300	37,200	17,200	23,500	--	3,000	--	214,000[2]
Pleasure Boats												
1980	780	1,845	400	3,668	4,056	5,220	3,000	650	8,600	1,120	2,420	31,759
2000	1,410	3,375	770	6,198	8,666	15,500	7,100	1,430	17,280	1,900	4,210	67,839
2020	2,490	5,985	1,500	10,588	17,656	35,500	15,050	2,180	30,580	2,620	7,260	131,409
Power Gigawatt Hours												
1980	--	--	--	--	--	--	--	--	--	--	--	30,900
2000	--	--	--	--	--	--	--	--	--	--	--	125,100
2020	--	--	--	--	--	--	--	--	--	--	--	382,600
Flood Control $1000 Damage Reduction												
1980	1,210	4,340	380	--	3,520	780	151	69	68	38	--	10,556
2000	1,970	7,060	690	--	6,370	1,700	301	110	100	54	--	18,355
2020	3,350	12,030	1,310	--	13,100	3,740	602	160	158	80	--	34,530

[1] Cumulative net needs. See basins for derivation.

[2] Includes commerce of minor ports not shown in individual basins.

Source: Appendices VI through XIV.

TABLE 2-26. Summary of needs, Puget Sound Area[1] (Cont'd)

Feature / Units and Years	BASINS: Nooksack-Sumas	Skagit-Samish	Stillaguamish	Whidbey-Camano Islands	Snohomish	Cedar-Green	Puyallup	Nisqually-Deschutes	West Sound	Elwha-Dungeness	San Juan Islands	Puget Sound Area
Watershed Management												
Flood prevention, 1000 acres												
1980	113	120.9	24.5	24.6	65.6	50.4	48.1	30.3	44.5	15.9	17.3	555.1
2000	113	120.9	24.5	24.6	65.6	50.4	48.1	30.3	44.5	15.9	17.3	555.1
2020	113	120.9	24.5	24.6	65.6	50.4	48.1	30.3	44.5	15.9	17.3	555.1
Watershed prevention and protection, 1000 acres												
1980	792.2	1,912.6	433.6	133.0	1,194.6	704.2	759.0	635.6	1,281.4	446.6	111.6	8,404.4
2000	792.2	1,912.6	433.6	133.0	1,194.6	704.2	759.0	635.6	1,281.4	446.6	111.6	8,404.4
2020	792.2	1,912.6	433.6	133.0	1,194.6	704.2	759.0	635.6	1,281.4	446.6	111.6	8,404.4
Water management–agricultural, 1000 acres												
1980	55.4	49.0	13.5	8.6	25.7	10.6	12.0	5.3	17.1	9.6	9.9	216.7
2000	92.3	81.7	22.6	14.4	42.9	17.8	19.9	9.0	28.6	16.1	16.4	361.7
2020	123.1	108.9	30.1	19.2	57.2	23.7	26.6	11.9	38.1	21.4	21.9	482.1
Water management–urban, 1000 acres												
1980	33.6	38.9	12.6	23.4	65.7	264.9	123.2	39.8	106.4	11.0	11.9	731.4
2000	33.6	38.9	12.6	23.4	81.0	317.3	123.6	39.8	106.4	11.0	11.9	799.5
2020	33.6	38.9	13.0	23.4	130.1	433.7	198.5	39.8	106.4	11.0	11.9	1,040.3
Recreation, 1000 user-days												
1980	2,600	3,000	1,240	2,260	5,200	5,700	3,100	2,590	5,100	900	1,400	33,090
2000	6,300	7,000	2,640	4,300	12,000	14,400	7,800	5,900	12,700	1,850	3,000	77,890
2020	12,900	13,900	5,140	9,300	24,000	29,900	16,100	12,800	26,200	3,950	6,000	160,190
Fish and Wildlife												
Sport fishing, 1000 user-days												
1980	170	572	230	132	625	506	492	401	424	145	66	3,763
2000	425	1,431	562	375	1,534	1,266	1,250	1,016	1,064	394	194	9,511
2020	835	2,828	1,107	748	3,024	2,516	2,476	2,009	2,097	887	389	18,916
Hunting, 1000 user-days												
1980	69	148	51	51	92	50	69	67	120	24	46	788
2000	159	339	116	116	212	116	159	154	274	55	105	1,805
2020	213	455	155	156	284	156	213	206	368	73	141	2,420
Commercial fishing, 1000 pounds												
1980	115	360	3,133	--	2,551	692	108	123	278	922	--	8,282
2000	2,610	3,692	5,290	--	3,387	2,186	1,928	2,191	5,169	1,441	--	27,894
2020	4,278	7,940	7,366	--	6,202	4,922	4,278	4,197	8,869	1,643	--	49,695

provided for as a part of the total Comprehensive Plan. In most basins a plan has been prepared that is responsive to the planning objectives and expressed desires of local residents. However, in two of the major basins the competing demands could not be resolved and alternative plans are presented.

Two alternative plans have been developed for the Skagit-Samish Basins and for the Nisqually-Deschutes Basins to aid in the determination of future development. In the Skagit-Samish Basins, Alternative A allows full use of storage opportunities to obtain maximum flood control in the Skagit River Basin. The assumption is made under this Alternative that no part of the Skagit River or its tributaries would be included in the National Wild and Scenic Rivers system. However, portions of the Skagit River system would be included for study under a State recreational river system. Alternative B is based on the assumption that the entire 165-mile river complex cited in the Act would be designated in the National Wild and Scenic Rivers system. The assumption is also made that the entire complex would be given a "Recreational River" classification and that non-storage developments would be compatible with this classification. Considerable portions of each Alternative are the same and would not be affected by the river classifications.

In the Nisqually-Deschutes Basins, Alternative A would allow for a projected recreation-wildlife and biotic research use of the Nisqually River delta. Alternative B provides for the utilization of a portion of the delta as a navigation port and for related industrial development.

Early Action 1970-1980

The early action portion of the Comprehensive Plan for the Puget Sound Area include management programs for water quality control of rivers and marine waters; development and dissemination of flood plain information; watershed practices of land treatment, flood prevention, water management and urban drainage; and fish and wildlife programs. Projects include such measures as diversion structures for municipal and industrial water supply, river pumping plants for irrigation, channel deepening and construction for navigation, levees and channel improvements for flood control, drainage control structures in small watersheds, recreation facilities and fish ladders, hatcheries, and game farms. Other projects include both small stream impoundments and large reservoirs to capture excess runoff for flood control and to provide storage for low flow augmentation for fish use, municipal and industrial water supply, water quality improvement and irrigation. Hydroelectric power is included where justified as a multiple-purpose feature of storage projects. Table 2-27 summarizes the early action portion of the Comprehensive Plan by alternative combinations of basin plans. Shown are management programs and nonstorage projects with cumulative program costs for the period 1970-1980 and the average annual benefits and cost for projects and programs required for implementation prior to 1980. Also shown are the capital investment costs for this period. Multiple-purpose storage projects scheduled for early action are indicated in Table 2-28.

Projects to satisfy municipal and industrial water supply needs of the Puget Sound Area residents include development of additional ground water resources and diversion or pumping from streams. An investment for nonstorage projects and allocated costs of storage projects of $138,741,000 is estimated for the satisfaction of 1980 level of water supply needs with most of this investment planned for surface water development. The Cedar-Green Basins and the Whidbey-Camano Islands would account for the major share of municipal and industrial water supply investment for nonstorage facilities prior to 1980.

Ground and surface water would be further utilized to satisfy the irrigation needs of the Puget Sound Area with the major water consumption occurring in the Nooksack-Sumas, Skagit-Samish, Snohomish and Elwha-Dungeness Basins which require nearly 98,000 acre-feet of water over that now consumed to meet the 1980 level of need. Nonstorage project investment for irrigation developments amount to $21,485,000 over this period.

Water quality control and treatment investment required prior to 1980 to complement existing treatment would amount to $11,930,000 for programs and $230,161,000 for collection and treatment facilities to be constructed in all basins. Major investments would occur in the Snohomish and Cedar-Green and Puyallup Basins where most of the Area's population and industry is concentrated.

Navigation improvement planned for early action include fourteen channel dredging projects in six of the basins, representing an investment of over $15,394,000 for deepening existing channels to service the deeper draft vessels. Major improvements are planned for the Puyallup Basin with the Snohomish

and Cedar-Green Basins also requiring large investments in order to provide channels of sufficient depths to accommodate changing draft requirements of the world's fleet.

Flood control measures which would be implemented prior to 1980 include flood plain management programs which are estimated to cost $811,000 and about 65 miles of levees and 36 miles of channel improvements. There are five channel improvement projects planned in four of the basins and six levee improvement projects planned in five of the basins, representing an investment of $65,400,000 for these measures excluding cost of the Avon Bypass. The cost of the Avon Bypass planned for Skagit-Samish Basins would depend upon whether the alternative providing for the Lower Sauk storage project is chosen or not. With the Lower Sauk project the bypass would cost $28,300,000. Without it the bypass would cost $36,300,000.

Twenty-five small watershed projects are proposed for early action at a total investment of $33,989,000, with the majority of the projects planned for the Nooksack-Sumas and Puyallup Basins. These projects involve improvement and stabilization of channels and, in some instances, construction of control structures. Complementary watershed management programs would cost an estimated $831,040,000.

A *significant investment* would be required prior to 1980 in order to satisfy the recreation needs of the Puget Sound Area. The investment program for early action amounts to over $406,965,000 with the major share of this investment scheduled for the basins draining into the eastern portion of Puget Sound. Planned recreation investments include land acquisition and camping, picnicking, boating and other facilities necessary to provide for a suitable recreational experience. A number of rivers would be studied for possible inclusion within a State Recreational River system.

Management measures for fish and wildlife enhancement are estimated to cost $2,992,000 and investments planned for spawning channels, hatcheries, game farms, fish ladders and stream clearance projects amount to $47,839,000 excluding the Nisqually-Deschutes Basins. With navigation development of the Nisqually Delta investment for fish and wildlife measure in those basins would amount to $2,551,000; without navigation development in the delta this investment would be $5,051,000.

Total investments for storage projects planned for early action are estimated at $165,103,000 with projects planned on the South Fork of the Nooksack River at a site near Edfro Creek; on the North and Middle Forks of the Snoqualmie River; on the Sultan River through second stage construction of Culmback Dam; and on the Cedar River near the outlet at Chester Morse Lake. These are multiple-purpose projects providing flood control storage and satisfying the needs of other purposes including municipal and industrial water supply, recreation, low flow augmentation for fishery enhancement, and electric power production. Adjustments in power operation at several existing reservoirs are indicated in Table 2-28. These include the Upper Baker Dam, in the Skagit-Samish Basins, with power production reduced in order to provide for flood control storage, and in the Nisqually-Deschutes Basins the Alder Dam reservoir project would be operated to provide flood control on a firm basis with little or no reduction of power generation. The annual repayment of power losses is estimated at $133,000 for the Upper Baker project.

A coordinated sea coast resource management program is recommended which provides for an appraisal of the present and potential resource, a determination of opportunities for multiple use and preparation of guidelines for future use.

TABLE 2-27. Costs and benefits—early action (1970-1980) portion of Comprehensive Plan, Puget Sound Area ($1000)

Features	Basins													Puget Sound Area			
	Nooksack-Sumas	Skagit-Samish Alt. A	Skagit-Samish Alt. B	Stillaguamish	Whidbey-Camano Islands	Snohomish	Cedar-Green	Puyallup	Nisqually-Deschutes Alt. A	Nisqually-Deschutes Alt. B	West Sound	Elwha-Dungeness	San Juan Islands	Alt. A–S.S.[5] Alt. A–N.D.[6]	Alt. A–S.S. Alt. B–N.D.	Alt. B–S.S. Alt. A–N.D.	Alt. B–S.S. Alt. B–N.D.
Management Programs[1]																	
Water Quality Monitoring, Evaluation and Control																	
Invest. Cost	840	490	490	160	250	2,400	3,400	2,600	350	350	750	350	340	11,930	11,930	11,930	11,930
Flood Plain Mgmt.																	
Invest. Cost	46	115	115	25	0	55	147	185	82	82	125	31	0	811	811	811	811
Watershed Mgmt. Programs[4]																	
Invest. Cost	60,532	87,556	87,556	28,693	16,266	108,504	225,954	135,672	40,710	40,710	97,404	17,852	11,897	831,040	831,040	831,040	831,040
Fish & Wildlife Programs																	
Invest. Cost	488	253	253	160	15	450	440	403	127	127	465	176	15	2,992	2,992	2,992	2,992
Total Management																	
Invest. Cost $1000	61,906	88,414	88,414	29,038	16,531	111,409	229,941	138,860	41,269	41,269	98,744	18,409	12,252	846,773	846,773	846,773	846,773
Nonstorage Projects																	
M&I Water Supply																	
Ground Water																	
Invest. Cost	1,663	0	0	564	216	180	2,400	13,154	1,290	1,290	2,470	24	670	22,631	22,631	22,631	22,631
Av. Ann. Cost	192	0	0	75	25	20	362	1,239	168	168	279	6	21				
Av. Ann. Benefits	192	0	0	75	25	20	362	1,239	168	168	279	6	21				
Net Ann. Benefits	0	0	0	0	0	0	0	0	0	0	0	0	0				
Surface Water																	
Invest. Cost	7,112	5,440	5,440	0	10,100	28,743	19,304	28,909	0	0	5,850	1,440	0	106,898	106,898	106,898	106,898
Ann. Cost	1,073	503	503	0	634	2,512	2,973	2,818	0	0	688	1,673	0				
Ann. Benefits	1,073	503	503	0	634	2,512	2,973	2,818	0	0	688	1,673	0				
Net Ann. Benefits	0	0	0	0	0	0	0	0	0	0	0	0	0				
Irrigation																	
Ground Water																	
Invest. Cost	2,230	1,072	1,072	270	0	135	0	136	273	273	0	0	0	4,116	4,116	4,116	4,116
Ann. Cost	311	179	179	45	0	22	0	17	32	32	0	0	0				
Ann. Benefits	311	179	179	45	0	22	0	17	32	32	0	0	0				
Net Ann. Benefits	0	0	0	0	0	0	0	0	0	0	0	0	0				
Surface Water																	
Invest. Cost	470	278	278	270	0	690	0	204	27	27	50	15,380	0	17,369	17,369	17,369	17,369
Ann. Cost	35	46	46	45	0	114	0	26	3	3	7	897	0				
Ann. Benefits	35	46	46	45	0	114	0	26	3	3	7	1,467	0				
Net Ann. Benefits	0	0	0	0	0	0	0	0	0	0	0	570	0				
Water Quality Control Treatment																	
Invest. Cost	15,800	4,880	4,880	1,860	3,187	97,390	113,850	34,000	5,375	5,375	10,900	13,595	1,824	302,661	302,661	302,661	302,661
Av. Ann. Costs	998	320	320	127	208	5,662	6,770	1,964	289	289	676	713	44				
Ann. Benefits	998	320	320	127	208	5,662	6,770	1,964	289	289	676	713	44				
Net Ann. Benefits	0	0	0	0	0	0	0	0	0	0	0	0	0				

Navigation																	
Invest. Cost	667	1,465	1,465	0	0	2,200	3,779	5,430	1,853	1,853	0	0	0	15,394	15,394	15,394	15,394
Av. Ann. Cost	36	81	81	0	0	120	191	318	92	92	0	0	0				
Av. Ann. Benefits	42	105	105	0	0	172	339	389	138	138	0	0	0				
Net Ann. Benefits	6	24	24	0	0	52	148	71	46	46	0	0	0				
Small Boat Harbors[2]																	
Invest. Cost	(1,766)	(1,714)	(1,714)	0	(4,648)	(6,306)	(4,139)	(3,120)	(459)	(459)	(8,685)	(1,434)	(2,951)	(35,222)	(35,222)	(35,222)	(35,222)
Av. Ann. Cost	(105)	(109)	(109)	0	(298)	(404)	(280)	(200)	(29)	(29)	(556)	(92)	(189)				
Av. Ann. Benefits	(164)	(159)	(159)	0	(431)	(585)	(391)	(290)	(43)	(43)	(806)	(133)	(274)				
Net Ann. Benefits	(59)	(50)	(50)	0	(133)	(181)	(111)	(90)	(14)	(14)	(250)	(41)	(85)				
Power	--	--	--	--	--	--	--	--	--	--	--	--	--				
Flood Control																	
Invest. Cost	2,500	37,800	45,800	7,700	0	31,950	12,000	1,600	0	0	150	0	0	93,700	93,700	101,700	101,700
Ann. Costs	125	2,116	2,536	454	0	1,545	601	86	0	0	11	0	0				
Ann. Benefits	141	3,450	3,778	500	0	4,130	723	103	0	0	12	0	0				
Net Ann. Benefits	16	1,334	1,242	46	0	2,585	122	17	0	0	1	0	0				
Watershed Management																	
Invest. Cost	10,973	10,637	10,637	1,645	0	2,503	2,180	4,972	0	0	1,079	0	0	33,989	33,989	33,989	33,989
Ann. Costs	614	594	594	92	0	142	119	271	0	0	59	0	0				
Ann. Benefits	2,269	2,242	2,242	288	0	397	242	382	0	0	150	0	0				
Net Ann. Benefits	1,655	1,648	1,648	196	0	255	123	111	0	0	91	0	0				
Recreation																	
Invest. Cost	25,680	35,814	35,814	20,420	28,450	60,900	54,425	35,389	21,951	21,951	62,212	8,259	15,224	368,724	368,724	368,724	368,724
Ann. Costs	1,743	2,555	2,555	1,256	2,257	4,039	3,792	2,339	1,697	1,697	5,405	698	1,112				
Ann. Benefits	3,156	3,600	3,600	1,484	2,715	5,720	4,560	3,255	2,590	2,590	6,000	1,125	2,700				
Net Ann. Benefits	1,413	1,045	1,045	228	458	1,681	768	916	893	893	595	427	1,588				
Fish & Wildlife																	
Invest. Cost	3,455	11,799	11,799	5,220	577	8,797	5,067	3,306	5,051	2,551	6,284	2,749	585	52,890	50,390	52,890	50,390
Av. Ann. Costs	271	1,420	1,420	521	42	987	438	366	494	347	583	282	47				
Av. Ann. Benefits	534	1,910	1,910	1,528	484	2,728	1,026	849	1,456	1,313	1,571	1,758	103				
Net Ann. Benefits	263	490	490	1,007	442	1,741	588	483	962	966	988	1,476	56				
Total Nonstorage																	
Invest. Cost	70,550	109,185	117,185	37,949	42,530	160,988	213,005	127,100	35,820	33,320	88,995	41,447	18,303	945,872	943,372	953,872	951,372
Av. Ann. Costs	5,398	7,911	8,331	2,615	3,166	11,017	15,246	9,444	2,775	2,628	7,708	4,269	1,224				
Av. Ann. Benefits	8,751	12,355	12,683	4,092	4,066	17,331	16,995	11,042	4,676	4,533	9,383	6,742	2,868				
Net Ann. Benefits	3,353	4,444	4,352	1,477	900	6,314	1,749	1,598	1,901	1,905	1,675	2,473	1,644				
Total Storage[3]																	
Invest. Cost	27,200	0	0	0	0	132,293	5,610	--	0	0	0	0	0	165,103	165,103	165,103	165,103
Av. Ann. Costs	1,540	133	133	0	0	7,008	312	--	0	0	0	0	0				
Av. Ann. Benefits	1,690	300	300	0	0	8,177	353	--	82	82	0	0	0				
Net Ann. Benefits	150	167	167	0	0	1,169	41	--	82	82	0	0	0				
Total Plan																	
Invest. Cost	$159,656	$197,599	$205,599	$66,987	$59,061	$404,690	$448,556	$265,960	$77,089	$74,589	$187,739	$59,856	$30,555	$2,030,248	$2,027,748	$2,038,248	$2,035,748

[1] Shown are cumulative annual program costs from 1970 to 1980.

[2] Included with Recreation.

[3] For feature data see Table 2-28, Storage Projects, Puget Sound Area.

[4] Does not include operation and maintenance costs or other program costs not distributed by basin.

[5] Alternative A—Skagit-Samish Basins.

[6] Alternative A—Nisqually-Deschutes Basins.

TABLE 2-28. Costs and benefits—early action (1970-1980) storage projects, Puget Sound Area ($1000)

Features	Basins								
	Nooksack-Sumas	Skagit-Samish	Snohomish				Cedar-Green	Nisqually-Deschutes	
	(Edfro)	Upper Baker	Culmback (Sultan)	North Fork Snoqualmie	Middle Fork Snoqualmie	Total Snohomish	Chester Morse Lake	Alder Dam and Reservoir	Puget Sound Area
M&I Water Supply									
Investment Cost	2,414		6,798			6,798			9,212
Av. Ann. Cost	137		318			318			455
Av. Ann. Benefits	150		350			350			500
Net Ann. Benefits	13		32			32			45
Flood Control									
Investment Cost	22,935		8,642	12,138	25,088	45,868	4,740	0	73,543
Av. Ann. Cost	1,298	133	443	665	1,169	2,277	263	0	3,971
Av. Ann. Benefits	1,425	300	707	690	1,657	3,054	298	39	5,116
Net Ann. Benefits	127	167	264	25	488	777	35	39	1,145
Power									
Investment Cost				32,845		32,845			32,845
Av. Ann. Cost				1,798		1,798			1,798
Av. Ann. Benefits				1,867		1,867			1,867
Net Ann. Benefits				69		69			69
Recreation									
Investment Cost	1,609			16,959	19,683	36,642			38,251
Av. Ann. Cost	92			929	1,184	2,113			2,205
Av. Ann. Benefits	100			964	1,296	2,260			2,360
Net Ann. Benefits	8			35	112	147			155
Fish and Wildlife									
Investment Cost	242		7,604	1,618	918	10,140	870	0	11,252
Av. Ann. Cost	13		369	89	44	502	49	0	564
Av. Ann. Benefits	15		500	92	54	646	55	43	759
Net Ann. Benefits	2		131	3	10	144	6	43	195
Total Storage									
Investment Cost	27,200		23,044	63,560	45,689	132,293	5,610	0	165,103
Av. Ann. Cost	1,540	133	1,130	3,481	2,397	7,008	312	0	8,993
Av. Ann. Benefits	1,690	300	1,557	3,613	3,007	8,177	353	82	10,602
Net Ann. Benefits	150	167	427	132	610	1,169	41	82	1,609

Long-Range 1980-2020

The long-range features of the Comprehensive Plan, including management programs and projects, requiring implementation after 1980 and before the year 2020, are reflected in the cumulative program costs contained in Table 2-29 and capital investment costs shown in Table 2-30 for projects.

An investment of $419,215,000 would be required after 1980 to satisfy the municipal and industrial water supply needs in the Puget Sound Area to the year 2020. Further ground water development and the use of diversion and storage are planned with interbasin water transfer occurring in three of the eleven river basins.

Several project-type irrigation developments are planned after 1980 with one of these being in the Skagit-Samish Basins and the other in the Nooksack-Sumas Basins. Major future irrigation development would be undertaken by private means. An investment of $51,362,000 is estimated as being necessary to satisfy irrigation needs between 1980 and the year 2020.

A continuation of substantial investments begun prior to 1980 would be carried out in the long-range period for water quality control and treatment commensurate with the expanding population and industrial base projected for the Puget Sound Area. Between 1980 and 2020 approximately $29,418,000 would be invested for water quality control programs and $935,757,000 for projects.

Further navigation improvements are anticipated with channel dredging required to accommodate the deeper draft vessels. Major navigation development is anticipated in the Skagit-Samish, Snohomish and Puyallup Basins in the long-range period at an estimated cost of $29,646,000 excluding development of the Nisqually Delta in the Nisqually-Deschutes Basins. Under one alternative plan for the Nisqually-Deschutes Basins a major port facility would be provided in the Nisqually River delta with channel dredging costs of $2,400,000. About 67 small boat harbor projects would be constructed in the long-range period providing over 83,000 wet moorages with costs of these facilities included with recreation.

The gross power requirements for the Puget Sound Area were defined for this study with a tentative schedule for satisfying the requirements indicated through use of imported power, further hydropower development and thermo-nuclear power installations in the Area. A number of nuclear-fired electric generating plants are anticipated to complement the Northwest Regional power supply which is primarily based on hydroelectric power. In the Nooksack-Sumas Basins power would be a feature of the multiple-purpose North Fork storage project. In the Skagit-Samish Basins under one alternative plan a storage project would be constructed on the Lower Sauk River. Included with this project would be the installation of electric power generating facilities. Some of the numerous pumped-storage sites which exist within the Puget Sound Area would be developed during the long-range period.

Additional flood control projects in the form of levees and channel improvements and impoundments are planned to meet expanding urban developments anticipated in portions of the flood plain. Over 75 miles of levees and 7 miles of channel improvements would be constructed and flood control storage would be provided by four projects under one alternative plan and at five projects under another. Flood plain management measures would cost $1,960,000. These flood control feature measures would significantly help reduce the level of future flood damages projected for the Area and cost from $152,535,000 to $213,535,000 depending on the plan selected.

Eighty-five small watershed projects are contained in the long-range portion of the Plan at an estimated cost of $62,198,000. Complementary watershed management programs would be undertaken to insure that the watershed management needs of the Area are satisfied. These would cost an estimated $1,823,216,000.

Over 900 recreation sites would be developed or expanded requiring substantial investments with over $1,223,240,000 estimated for facilities during the long-range period. These sites would be constructed throughout the Puget Sound Area.

Spawning channels, hatcheries and other measures for fish and wildlife enhancement are planned at an estimated cost of $205,833,000 with $9,230,000 included for program measures.

The total planned investment in the long-range period ranges from $4,961,650,000 to $5,093,050,000 depending on the alternative plan selected for the Area. This, combined with the investments during the early action period, provides a total planned investment for management of from $6,999,898,000 to $7,120,798,000 for the 50-year planning period.

Several additional storage projects are planned

TABLE 2-29. Total program investment costs, Puget Sound Area ($1000)

Feature and Period	Nooksack-Sumas	Skagit-Samish	Stillaguamish	Whidbey-Camano Islands	Snohomish	Cedar-Green	Puyallup	Nisqually-Deschutes	West Sound	Elwha Dungeness	San Juan Islands	Puget Sound Area
Water Quality Control												
1970-1980	840	490	160	250	2,400	3,400	2,600	350	750	350	340	11,930
1980-2000	710	360	300	200	2,512	4,840	4,200	240	360	440	160	14,322
2000-2020	790	420	340	240	1,400	5,320	5,100	286	480	520	200	15,096
Total	2,340	1,270	800	690	6,312	13,560	11,900	876	1,590	1,310	700	41,348
Flood Control												
1970-1980	46	115	25	0	55	147	185	82	125	31	0	811
1980-2000	92	168	46	0	100	240	100	114	100	20	0	980
2000-2020	92	168	46	0	100	240	100	114	100	20	0	980
Total	230	451	117	0	255	627	385	310	325	71	0	2,771
Watershed Management												
1970-1980	60,532	87,556	28,693	16,266	108,504	225,954	135,672	40,710	97,404	17,852	11,897	831,040
1980-2000	70,389	99,226	29,480	18,412	134,227	230,301	94,123	68,131	121,702	23,229	13,989	903,209
2000-2020	65,373	109,318	28,547	19,642	135,540	230,044	138,264	34,506	120,616	24,437	13,720	920,007
Total	196,294	296,100	86,720	54,320	378,271	686,299	368,059	143,347	339,722	65,518	39,606	2,654,256[1]
Fish and Wildlife												
1970-1980	488	253	160	15	450	440	403	127	465	176	15	2,992[2]
1980-2000	430	200	320	15	750	602	630	478	800	309	0	4,534
2000-2020	435	200	320	15	750	776	630	470	800	300	0	4,696
Total	1,353	653	800	45	1,950	1,818	1,663	1,075	2,065	785	15	12,222[2]
Total All Programs												
1970-1980	61,906	88,414	29,038	16,531	111,409	229,941	138,860	41,269	98,744	18,409	12,252	846,773
1980-2000	71,621	99,954	30,146	18,627	137,589	235,983	99,053	68,963	122,962	23,998	14,149	923,045
2000-2020	66,690	110,106	29,253	19,897	137,790	236,380	144,094	35,376	121,996	25,277	13,920	940,779
Total	200,217	298,474	88,437	55,055	386,788	702,304	382,007	145,608	343,702	67,684	40,321	2,710,597

[1] Does not include $237,220,000 in program costs for beach erosion and sediment studies, soil surveys, etc., planned for the Puget Sound Area but not apportioned by basins.

[2] Does not include $388,000 for stream surveys planned for Puget Sound Area.

after 1980. These include a project on the North Fork of the Nooksack River in the Nooksack-Sumas Basins. Under one alternative plan for the Skagit-Samish Basins a storage project would be constructed on the Sauk River. Modification of the outlet works on the South Fork of the Tolt River, an existing facility operated by the city of Seattle for water supply purposes, also would be undertaken after 1980 in the Snohomish Basin to provide flood control storage. A project on the North Fork of the Snoqualmie River planned for implementation prior to 1980 is considered as a source of additional water supply for Seattle in the long-range period. Second stage construction of this facility would provide supplemental water to meet the needs of the city. In the Cedar-Green Basins additional storage would be provided on the Cedar River possibly above Chester Morse Lake with an impoundment on the Rex River in order to satisfy municipal and industrial water needs of Seattle. A storage project on the Puyallup River is planned for controlling flooding of urban and agricultural lands. The Puyallup River project would probably be a multiple-purpose project providing benefits for recreation and possibly low flow augmentation for fish and other purposes depending on findings of future detailed studies. A storage project is planned at the Shellrock Ridge site on the Deschutes River after the year 2000 in the Nisqually-Deschutes Basins. In the Elwha-Dungeness Basins the existing dam below Lake Aldwell would be modified to increase utilization of existing storage.

TABLE 2-30. Total project investment costs, Puget Sound Area ($1000)

Feature and Period	Nooksack-Sumas	Skagit-Samish Alt. A	Skagit-Samish Alt. B	Stillaguamish	Whidbey-Camano Islands	Snohomish	Cedar-Green	Puyallup
M&I Water Supply								
1970-1980	11,189	5,440	5,440	564	10,316	35,721	21,704	42,063
1980-2000	9,077	8,125	8,125	858	2,500	64,382	74,520	36,516
2000-2020	4,998	11,290	11,290	1,152	0	19,465	87,847	59,607
Total	25,264	24,855	24,855	2,574	12,816	119,568	184,071	138,186
Irrigation								
1970-1980	2,700	1,350	1,350	540	0	825	0	340
1980-2000	22,240	7,100	7,100	540	0	527	55	680
2000-2020	0	17,750	17,750	0	0	175	55	340
Total	24,940	26,200	26,200	1,080	0	1,527	110	1,360
Water Quality Control								
1970-1980	15,800	4,880	4,880	1,860	3,187	97,390	113,850	34,000
1980-2000	19,030	8,050	8,050	3,294	8,110	32,480	275,800	51,200
2000-2020	37,080	8,900	8,900	3,980	10,345	43,700	237,000	79,600
Total	71,910	21,830	21,830	9,134	21,642	173,570	626,650	164,800
Navigation								
1970-1980	667	1,465	1,465	0	0	2,200	3,779	5,430
1980-2000	1,343	9,417	9,417	0	0	7,696	0	4,488
2000-2020	0	2,989	2,989	0	0	0	0	0
Total	2,010	13,871	13,871	0	0	9,896	3,779	9,918
Power								
1970-1980	0	0	0	0	0	32,845	0	0
1980-2000	20,000	68,000	0	0	0	0	0	0
2000-2020	0	0	0	0	0	0	0	0
Total	20,000	68,000	0	0	0	32,845	0	0
Flood Control								
1970-1980	25,435	37,800	45,800	7,700	0	77,818	16,740	1,600
1980-2000	26,760	65,800	7,800	3,700	0	39,870	1,300	27,500
2000-2020	0	0	0	0	0	36,255	0	0
Total	52,195	103,600	53,600	11,400	0	153,943	18,040	29,100
Watershed Management								
1970-1980	10,973	10,637	10,637	1,645	0	2,503	2,180	4,972
1980-2000	5,950	1,850	1,850	5,620	3,245	12,387	5,510	4,167
2000-2020	936	1,460	1,460	1,310	0	100	200	0
Total	17,859	13,947	13,947	8,575	3,245	14,990	7,890	9,139
Recreation								
1970-1980	27,289	35,814	35,814	20,420	28,450	97,542	54,425	35,389
1980-2000	27,200	42,700	42,700	20,800	31,800	69,500	70,000	55,600
2000-2020	49,800	71,300	71,300	40,200	51,900	123,200	104,600	88,040
Total	104,289	149,814	149,814	81,420	112,150	290,242	229,025	179,029
Fish and Wildlife								
1970-1980	3,697	11,799	11,799	5,220	577	18,937	5,937	3,306
1980-2000	11,167	18,909	18,909	5,568	528	12,294	7,916	8,039
2000-2020	13,610	23,035	23,035	9,412	734	18,220	16,517	11,864
Total	28,474	53,743	53,743	20,200	1,839	49,451	30,370	23,209
Total (All Features)								
1970-1980	97,750	109,185	117,185	37,949	42,530	365,781	218,615	127,100
1980-2000	142,767	229,951	103,951	40,380	46,183	239,136	435,101	188,190
2000-2020	106,424	136,724	136,724	56,054	62,979	241,115	446,219	239,451
Total	346,941	475,860	357,860	134,383	151,692	846,032	1,099,935	554,741

[1] Alternative A–Skagit-Samish Basins.

[2] Alternative A–Nisqually-Deschutes Basins.

Nisqually-Deschutes Alt. A	Nisqually-Deschutes Alt. B	West Sound	Elwha-Dungeness	San Juan Islands	Puget Sound Area: Alt. A–S.S.[1] Alt. A–N.D.[2]	Puget Sound Area: Alt. A–S.S. Alt. B–N.D.	Puget Sound Area: Alt. B–S.S. Alt. A–N.D.	Puget Sound Area: Alt. B–S.S. Alt. B–N.D.
1,290	1,290	8,320	1,464	670	138,741	138,741	138,741	138,741
435	435	18,190	2,678	10,200	227,481	227,481	227,481	227,481
1,167	1,167	5,360	848	0	191,734	191,734	191,734	191,734
2,892	2,892	31,870	4,990	10,870	557,956	557,956	557,956	557,956
300	300	50	15,380	0	21,485	21,485	21,485	21,485
680	680	70	0	0	31,892	31,892	31,892	31,892
1,080	1,080	70	0	0	19,470	19,470	19,470	19,470
2,060	2,060	190	15,380	0	72,847	72,847	72,847	72,847
5,375	5,375	10,900	13,595	1,824	302,661	302,661	302,661	302,661
6,760	6,760	25,300	9,760	2,968	442,752	442,752	442,752	442,752
10,200	10,200	37,300	21,300	3,600	493,005	493,005	493,005	493,005
22,335	22,335	73,500	44,655	8,392	1,238,418	1,238,418	1,238,418	1,238,418
1,853	1,853	0	0	0	15,394	15,394	15,394	15,394
3,713	6,113	0	0	0	26,657	29,057	26,657	29,057
0	0	0	0	0	2,989	2,989	2,989	2,989
5,566	7,966	0	0	0	45,040	47,440	45,040	47,440
0	0	0	0	0	32,845	32,845	32,845	82,845
0	0	0	0	0	88,000	88,000	20,000	20,000
0	0	0	0	0	0	0	0	0
0	0	0	0	0	120,845	120,845	52,845	52,845
0	0	150	0	0	167,243	167,243	175,243	175,243
0	3,000	1,140	0	0	166,070	169,070	108,070	111,070
3,500	3,500	0	2,750	0	42,505	42,505	42,505	42,505
3,500	6,500	1,290	2,750	0	375,818	378,818	325,818	328,818
0	0	1,079	0	0	33,989	33,989	33,989	33,989
4,340	4,340	8,055	2,962	2,736	56,822	56,822	56,822	56,822
100	100	970	300	0	5,376	5,376	5,376	5,376
4,440	4,440	10,104	3,262	2,736	96,187	96,187	96,187	96,187
21,951	21,951	62,212	8,259	15,224	406,975	406,975	406,975	406,975
30,200	30,200	82,100	12,700	16,200	458,800	458,800	458,800	458,800
53,700	53,700	133,700	19,800	28,200	764,440	764,440	764,440	764,440
105,851	105,851	278,012	40,759	59,624	1,630,215	1,630,215	1,630,215	1,630,215
5,051	2,551	6,284	2,749	585	64,142	61,642	64,142	61,642
5,612	5,612	13,389	3,474	580	87,476	87,476	87,476	87,476
7,437	7,437	14,854	1,998	676	118,357	118,357	118,357	118,357
18,100	15,600	34,527	8,221	1,841	269,975	267,475	269,975	267,475
35,820	33,320	88,995	41,447	18,303	1,183,475	1,180,975	1,191,475	1,188,975
51,740	57,140	148,244	31,457	32,684	1,585,950	1,591,350	1,459,950	1,465,350
77,184	77,184	192,254	46,996	32,476	1,637,876	1,637,876	1,637,876	1,637,876
164,744	167,644	429,493	120,017	83,463	4,407,301	4,410,201	4,289,301	4,292,201

FEATURES OF THE COMPREHENSIVE PLAN

The Comprehensive Plan summarized in Tables 2-27 through 2-30 is expanded in this section with a description of project and program features and an enumeration of investment costs required over the 50-year planning period.

Municipal and Industrial Water Supply

The Comprehensive Plan provides specific proposals for the satisfaction of municipal and industrial water supply needs of the various urban areas and rural communities through the utilization of both ground and surface water. Surface water derived from sources within each basin would be the main supply for eight of the eleven major river basins. Three of the basins would use or depend upon imported water from adjoining basins. These include the Whidbey-Camano Islands, Cedar-Green and Puyallup Basins. The quantity and the quality of the water supplies are adequate for all requirements. The total supply, transmission and treatment cost estimated to satisfy the Puget Sound Area municipal and industrial water supply needs over the 50-year planning period is estimated at $557,956,000 which averages $11,159,000 per year.

The early action program requires an investment of $138,741,000 for construction of supply and transmission facilities prior to 1980 to meet the level of needs projected for that year. Major water purveyors in the Cedar-Green and Puyallup Basins, which presently depend on imported water, would draw additionally upon these sources to a much greater extent, consistent with projected population and industrial expansions. In many of the basins a major portion of the early action needs can be met through expansion of the existing systems. However, significant projects would be required in several of the basins in order to meet the 1980 level needs. These include development of surface water supplies on the South Fork of the Nooksack River by the city of Bellingham through water stored at the proposed Edfro Dam; interbasin transfer of additional water to serve Whidbey Island by purchasing water from the city of Anacortes to the north, with the southern portion of the Island satisfied by a pipeline connecting to the mainland and serviced by the city of Everett; in the Snohomish Basin, second stage construction of Culmback Dam on the Sultan River would meet the 1980 level of needs of the city of Everett; in the Cedar-Green Basins additional interbasin transfer of water is planned to supply Seattle, with a diversion structure constructed on the North Fork of the Tolt River in the Snohomish Basin; and in the Puyallup Basin further utilization of conservation storage at the Howard Hanson Dam project on the Green River is recommended to satisfy the 1980 level of needs of the city of Tacoma. The Olympia service area in the Nisqually-Deschutes Basins is expected to continue obtaining its water supply through further development of ground water resources. The least costly means of satisfying water supply needs in most cases involves the expansion of existing systems, as is the case in the West Sound Basins. A Ranney well system is planned near the Elwha River to supplement the existing Morse Creek supply in the Elwha-Dungeness Basins to meet the needs of the city of Port Angeles.

After 1980 the Comprehensive Plan includes pumping and treating water from the Snohomish River by the city of Everett, to complement the Sultan River supply when the level of demand has reached the capacity of that source. Utilization of Lake Aldwell in the Elwha Basin to supply industrial water and other uses is recommended through modification of the outlet works to increase the conservation storage capabilities of the reservoir. Withdrawal and limited treatment of water from the Puyallup River would provide increased supply to the service area of Tacoma near the year 2000. Ground water would continue to serve as a supply during periods of surface water turbidity. Satisfaction of water supply needs in the San Juan Islands would entail use of the collection and storage capability of Mountain Lake and construction of a submerged pipeline from Orcas Island to other islands. Camano Island could receive water supply through an interbasin transfer from the Stillaguamish River.

Development of water supply by major purveyors and the consolidation of smaller water districts into larger regional supply and transmission systems is recommended to obtain economies of scale and to minimize the possible adverse impacts on the environment and water resource which could occur if every water district developed its own supply.

A total investment of $419,215,000 is estimated to be required to satisfy the municipal and industrial water supply needs of the Area from 1980 to 2020.

Irrigation

Future irrigation development is projected to be accomplished primarily through private means. In most locations where the ground and surface water supplies are adequate this can be economically developed by the individual farmers. However, in some areas project-type developments are considered to be the best means of bringing additional lands under irrigation. All the basins in the Area would have a net increase in land under irrigation except Whidbey-Camano and San Juan Islands, projected to remain at current levels of development and the Cedar-Green Basins where a net reduction in irrigated land is projected due to industrial and urban growth onto presently irrigated lands. Total investment costs for irrigation facilities over the 50-year planning period is estimated at $72,847,000, averaging $1,457,000 annually.

The early action plan sets forth the development of individual farm and project irrigation facilities costing $21,485,000. This includes diversion facilities, conveyance pipe, pumps, elevated storage tanks and on-farm distribution systems necessary to deliver the irrigation water to the individual farms. An increase of 46,300 acres of land above the current amount being irrigated is projected by the year 1980. Principal irrigation expansion is expected to occur in the Nooksack-Sumas, Skagit-Samish and Elwha-Dungeness Basins. These lands would be served by direct diversion from ground and surface sources. Storage would be necessary in only the Nooksack-Sumas Basins to provide the projected irrigation water supplies.

During the early action period all irrigation development is expected to be by the individual farmer except for the Sequim area in the Elwha-Dungeness Basins. Here a project-type development is projected which would update the existing open ditch irrigation system and serve 6,100 acres of additional lands. Water would be diverted from the Dungeness River and conveyed by gravity pipeline to elevated storage tanks from which it would be delivered to the farm lands with adequate pressure for sprinkler irrigation. The project is estimated to cost $14,610,000, with on-farm systems required by individual farmers amounting to $770,000, for a total project cost of $15,380,000.

The long-range plan projects an incremental increase in irrigated acreages of 85,000 acres between 1980 and 2020. Project-type developments are projected for the Nooksack-Sumas Basins prior to 2000 and the Skagit-Samish between 1980 and 2020. Storage would be necessary in the Nooksack-Sumas Basins. The projected multiple-purpose North Fork dam and reservoir, located on the North Fork of the Nooksack River would provide the needed irrigation water supplies. Water would be released from storage into the river diverted at selected downstream locations, and conveyed to irrigable lands.

Adequate natural streamflows are available to meet the projected irrigation needs in the Skagit-Samish Basins. Here water would be diverted from the river and conveyed by project facilities to farm headgates with adequate pressure for sprinkler irrigation.

The other lands projected for irrigation in the long-range period are located in small scattered tracts suitable for economic development by individual farmers. Adequate ground and surface water supplies are available to meet these needs.

The projected irrigation diversions and depletions for each basin are shown in Table 2-31.

A total investment of $51,362,000 is estimated to be required to satisfy the long-range irrigation needs for the period 1980 to 2020.

Irrigation of forest lands is largely in the experimental stages and, while not yet economically justified, may become so in the future. The Puget Sound Area is expected to provide a significant share of the national wood fiber needs through 2020. The expected demand would require accelerated growth inducement and management techniques. Should irrigation prove feasible under these circumstances, there is an estimated 635,000 acres of forest land that may be affected.

TABLE 2-31. Projected irrigation diversions and depletions (1000 acre-feet)

	Present				1980				2000				2020			
	Diversion		Depletion		Diversion		Depletion		Diversion		Depletion		Diversion		Depletion	
	SW	GW	SW	GW	SW	GW	SW	GW	SW	GW	SW	GW	SW	GW	SW	GW
Nooksack Sumas	29.0	44.0	20.0	30.0	33.0	78.0	23.0	53.0	71.0	78.0	49.0	53.0	71.0	78.0	49.0	53.0
Skagit Samish	3.6	8.4	3.5	8.0	7.6	23.5	7.2	22.9	17.6	32.7	16.5	32.2	55.6	42.7	53.7	41.5
Stillaguamish	3.5	1.3	2.4	0.9	7.5	5.0	5.1	3.6	11.5	8.7	7.8	6.3	11.5	8.7	7.8	6.3
Whidbey Camano Islands	1.9	5.5	1.9	5.5	1.9	5.5	1.9	5.5	1.9	5.5	1.9	5.5	1.9	5.5	1.9	5.5
Snohomish	11.9	12.6	8.9	8.3	20.9	7.3	10.4	9.1	26.4	9.3	14.2	10.4	28.9	9.3	15.9	10.4
Cedar Green	4.5	1.1	3.0	0.8	3.1	0.8	2.1	0.5	1.5	0.4	1.0	0.3	2.0	0.4	1.3	0.3
Puyallup	5.0	3.8	3.4	2.3	9.0	5.7	5.7	3.9	17.0	9.5	10.8	6.5	21.0	11.5	13.4	7.7
Nisqually Deschutes	8.1	5.2	5.3	3.4	8.6	9.9	5.6	6.5	11.0	19.4	7.1	12.7	15.0	34.3	9.7	22.5
West Sound	2.5	0.6	1.7	0.4	3.3	0.8	2.3	0.5	4.3	1.1	3.0	0.7	5.3	1.3	3.7	0.9
Elwha Dungeness	75.0	---	75.0	---	60.0	---	60.0	---	60.0	---	60.0	---	60.0		60.0	---
San Juan Islands	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Total	145.0	82.5	125.1	59.6	154.9	136.5	123.3	105.5	222.2	164.6	171.3	127.6	272.2	191.7	216.4	148.1

SW–Surface Water
GW–Ground Water

Source: Appendix VII.

Water Quality Control

The Comprehensive Plan provides for the satisfaction of water quality needs of the Puget Sound Area through water quality surveillance, construction of collection and treatment facilities, and consideration of minimum dilution flows in streams. Satisfaction of Federal and State standards for receiving waters and as set forth in the Implementation and Enforcement Plan for Interstate Waters, 1967, and as proposed for Intrastate Waters, 1969, of the State of Washington, can be achieved by implementation of the Plan. The cost of water quality control and collection and treatment facilities proposed over the 50-year planning period is estimated at $1,279,766,000, averaging $25,595,000 per year.

The early action program requires an investment of $230,161,000 to cosntruct collection and treatment facilities prior to 1980 to meet water quality objectives. Water quality surveillance pro-

The early action program requires an investment of $230,161,000 to construct collection and treatment facilities prior to 1980 to meet water quality objectives. Water quality control programs recommended for implementation prior to 1980, are estimated to cost $11,930,000, with water quality surveillance stations to be located in all eleven major river basins of the Puget Sound Area. The major water quality problems existing within the Area are largely the result of inadequately treated waste discharges from the paper and allied products and food and kindred products industries. Four bays in the Area have experienced significant water quality degradation due to discharges of these wastes. Provision of adequate treatment facilities by these industries represents the primary key to the solution of the major water quality problems. Discharges from pulp and paper plants are recommended for treatment including construction of sulphite removal facilities and adequate marine outfalls and diffusers. The pulp and paper products industry contributes a significant amount of the annual wasteload on receiving waters in the Puget Sound Area.

Major investments amounting to $113,850,000 prior to 1980 for water quality control and improvement are planned for the Cedar-Green Basins where over 50 percent of the Area population resides. Much of this program is currently underway by the Municipality of Metropolitan Seattle. Significant investments for water quality control and treatment are also indicated for the Snohomish and Puyallup Basins where $97,390,000 and $34,000,000, respectively, are scheduled for projects to be started prior to 1980. In the future, the program for adequate sewer construction would depend on the availability of economic resources and the decision of the people. Completion of the elements contained within the Comprehensive Plan for waste treatment and collection facilities and annual treatment costs would be at a fairly uniform annual level. Substantial investments would be required, however, for sewage collection facilities.

Streamflows in most basins are expected to be adequate in the future to assimilate residual waste discharges. Lake Washington would continue to require substantial fresh-water inflows to achieve and maintain adequate quality, with recovery from near

eutrophication dependent upon these inflows. A minimum flow in the Cedar River would be required to insure that nutrients formerly discharged into the lake are eventually flushed out. Inflow from the Cedar River also is required to insure that a sufficient amount of water is available to maintain an adequate level of the lake during the summer months when peak use of the Hiram Chittenden Locks occurs, resulting in salt water intrusion into Lake Union and the Ship Canal.

The long-range program for satisfying water quality needs of the Puget Sound Area provides for further construction of collection and treatment facilities commensurate with the location and intensity of growing urban and industrial developments projected for the Area. During the long-range period expansion by industry, new developments and growth of urban and recreation areas correspondingly would require that new sewer systems be installed and treatment facilities enlarged and/or constructed. A total estimated cost of the long-range period is estimated at $965,175,000 for the water quality improvement. This includes provision for a continuation of the control program initiated during the early action period.

Navigation

Future navigation needs of the Puget Sound Area would be provided through retention of lands having a potential for terminal and water transport-oriented industrial use and the scheduling of major river and harbor channel deepening projects to accommodate the growing draft of the world fleet. Channel projects are planned in six of the eleven basins, through the year 2000 in the Nooksack-Sumas, Snohomish, Cedar-Green, Puyallup, and Nisqually-Deschutes Basins and through 2020 in the Skagit-Samish Basins. The channel improvements and the retention of land areas for terminal and water transport-oriented industry would be necessary to service the annual waterborne commerce of nearly 252,000,000 tons projected for the Area by the year 2020, compared to 40,000,000 tons currently handled annually by Puget Sound Area ports. The harbor and channel projects planned for the 50-year planning period are estimated to range from $45,040,000 to $47,440,000, averaging about $900,000 each year depending on the alternative plan selected.

Pleasure boating, although included as one aspect of outdoor recreation with total costs and benefits of moorage facilities covered under that function, was accorded special study as a facet of navigation. Small boat harbors required to satisfy a major portion of present and future moorage needs are viewed as important navigation projects. The Comprehensive Plan contains these small boat harbors that would probably be undertaken by the public sector to satisfy the wet moorage needs of Puget Sound boaters.

The early action portion of the Comprehensive Plan calls for investments of $15,394,000 to deepen thirteen existing navigation channels and dredge one new channel for a total of approximately 28 miles of channel improvements (see Table 2-32) to enable vessels expected by 1980 to call at Puget Sound Area ports. Deepening of the Whatcom Creek waterway in the Nooksack-Sumas Basins would be undertaken to accommodate the large freighters that would be calling at the Port of Bellingham. Oil tankers that service refineries at Anacortes in the Skagit-Samish Basins would be provided with deeper draft channels up to 54 feet in depth. Major investments are planned for the Snohomish Basin with deepening of the Port of Everett's East Waterway and a portion of the shallow draft Snohomish River channel to accommodate deep draft vessels. The Duwamish River waterways in the Cedar-Green Basins also are scheduled for deepening as are the Port of Tacoma's existing waterways in the Puyallup Basin, and the West Waterway of Olympia Harbor in the Nisqually-Deschutes Basins.

Navigation land requirements through 1980 generally would be satisfied by expansion of existing facilities and use of areas already partially or wholly developed. However, some development of new lands in the Snohomish River delta would be needed by 1980. The undeveloped areas cited in Appendix VIII, Navigation, as having a favorable potential for development as terminal and/or water transport-oriented industrial land should be retained for future navigation related use. This would insure that land does not become a constraint to that portion of the Area's economy related to commercial navigation. However, the reservation of these favorable sites need not preclude interim use for other purposes.

Approximately 27 small boat harbor projects, providing nearly 30,000 wet moorages are proposed for construction by the public sector prior to 1980 as shown in Table 2-32. Wet moorage needs for the Stillaguamish Basin would be satisfied through development in the Skagit-Samish Basins as no

favorable sites were found in the former Basin. Also during the early action period a study would be undertaken to determine the requirements, size, and distribution of harbors of refuge needed to provide havens for small craft seeking shelter from sudden storms. The study would be undertaken over a period of 3 years at an estimated cost of $500,000. A comprehensive plan of development for harbors of refuge would be developed by the study with preliminary site layouts made of suitable locations along the shoreline of Puget Sound and adjacent waters. A preliminary economic analysis would be performed of each site to determine project feasibility. The study would be undertaken on a joint Federal-local basis.

The long-range portion of the Comprehensive Plan provides for the satisfaction of navigation needs through additional channel deepening commensurate with the increasing vessel drafts expected. Channels of up to 106-foot depth are planned to accommodate the super bulk carriers projected for the future, with channels up to 46 feet deep planned for freighters. A 46-foot channel is planned through the Nooksack River delta prior to the year 2000 as a new development. Deepening of the existing shallow draft channel in the Snohomish River and an extension of this waterway approximately 3 miles upstream to the head of Ebey Slough is also proposed in the long-range plan prior to the year 2000. Further channel deepening of existing channels is planned in the long-range period in the Nooksack-Sumas, Skagit-Samish, Snohomish, Puyallup, and Nisqually-Deschutes Basins. Long-range navigation improvements excluding development of the Nisqually River delta are estimated to cost $29,646,000. A deep draft channel in the Nisqually delta dredged to a 55-foot depth would have an estimated cost of $2,400,000.

On a long-range basis all sites are needed that have been designated as being favorable for navigation related development, including the Nisqually delta. The Plan provides for a multi-discipline study of the Nisqually delta to be undertaken during the early action period to determine whether port development in the delta can be undertaken compatible with wildlife and recreation use. If the Nisqually delta is not developed, an alternative site would be required to satisfy projected navigation land area needs. Lands now part of Indian Reservations or military reservations that were not considered as being available for development in this study would be reviewed and studied to determine possibilities for development as alternatives to the Nisqually delta. More intensive and efficient use of other lands also would be considered. However, present information indicates that the bulk cargo facilities proposed as part of the navigation development in the delta may not entirely be replaceable in other basins.

After 1980 the construction of 56 new small boat harbors and expansion of 11 existing facilities would provide wet moorages for pleasure boaters. All of the wet moorage needs projected for the Area cannot be satisfied at sites found to have suitable potential for development. Consequently, proportionate greater use of dry moorage is anticipated than currently is desired by boaters in order to meet moorage needs. In several of the basins, wet moorage needs, projected to the year 2000, can be satisfied in adjacent basins. However, needs projected to the year

TABLE 2-32. Navigation projects, Puget Sound Area

	Navigation Channels						Small Boat Harbors					
	By 1980		1980-2000		2000-2020		By 1980		1980-2000		2000-2020	
Basins	Number of Projects	Miles	Number of Projects	Miles	Number of Projects	Miles	Number of Projects	Wet Moorages	Number of Projects	Wet Moorages	Number of Projects	Wet Moorages
Nooksack-Sumas	1	1.5	2	2.8			2	870	1	550	1	1,150
Skagit-Samish	2	5.7	3	9.4	2	4.8	2	850	2	1,900	3	3,340
Stillaguamish												
Whidbey-Camano Is.							3	2,300	2	2,660	6	9,390
Snohomish	2	4.2	3	11.3			2	3,130	4	5,940	8	13,680
Cedar-Green	5	7.4					3	2,100	5	10,020		
Puyallup	3	5.4	2	2.1			2	1,550	1	2,720		
Nisqually-Deschutes												
Alternative A	1	3.8	2	5.9			1	230	2	2,180	2	1,210
Alternative B	1	3.8	3	6.5			1	230	2	2,180	2	1,210
West Sound							6	4,310	9	8,710	8	13,220
Elwha-Dungeness							2	710	3	800	1	700
San Juan Islands							4	1,480	4	1,800	5	3,040
Puget Sound Area												
Alternative A	14	28.0	12	31.5	2	4.8	27	17,530	33	37,280	34	45,730
Alternative B	14	28.0	13	22.1	2	4.8	27	17,530	33	37,280	34	45,730

2020 cannot be entirely satisfied for the Cedar-Green and Puyallup Basins even with this means.

Shown in Table 2-32 is a summary of navigation projects scheduled for construction after 1980.

Power

In the Pacific Northwest, planning for the satisfaction of electrical power needs is accomplished on a regional basis. The geographic and economic relationships between the Puget Sound Area and the surrounding region are inter-related. The region is served on a coordinated basis through a number of interconnected generating and transmission systems with the Federal regional transmission grid of the Bonnevile Power Administration providing the major lines.

As the Puget Sound Area is one of two major load centers of the region, its needs would have a strong influence on the regional rate of development. Presently the major outside source of power is from the Upper and Middle Columbia River hydroelectric plants. These plants could reach ultimate installed capacity by the 1990's, which coincides with the time that the transmission corridor across the North Cascade Mountains would be filled to capacity.

The Puget Sound Area would have a peak demand of 30,000 megawatts by the year 2000, almost ten times the present demand. Early in the period 1980-2000 the Area would begin developing nuclear-fueled steam-electric plants and pumped storage hydroelectric plants late in the period to meet the demand for power.

The Area has numerous nuclear-electric power sites utilizing various types of cooling, and many excellent pumped storage hydroelectric sites to meet the future power demands. Therefore, by the year 2020, when the electric power peak requirement is forecasted at almost 90,000 megawatts (nearly 30 times present demand) pumped storage and nuclear-electric generation is projected to dominate the scene.

Figure 2-5 illustrates the development of electric power resources in meeting energy and peak requirements from 1965 to 2020. The nuclear and miscellaneous portion includes geothermal or other unknown sources of generation. The pumped storage and fossil-fuel portion includes possible gas-turbine or steam-electric peaking plants.

Future new electric power developments within the Puget Sound Area would be determined by economies of location, and the impact on the natural

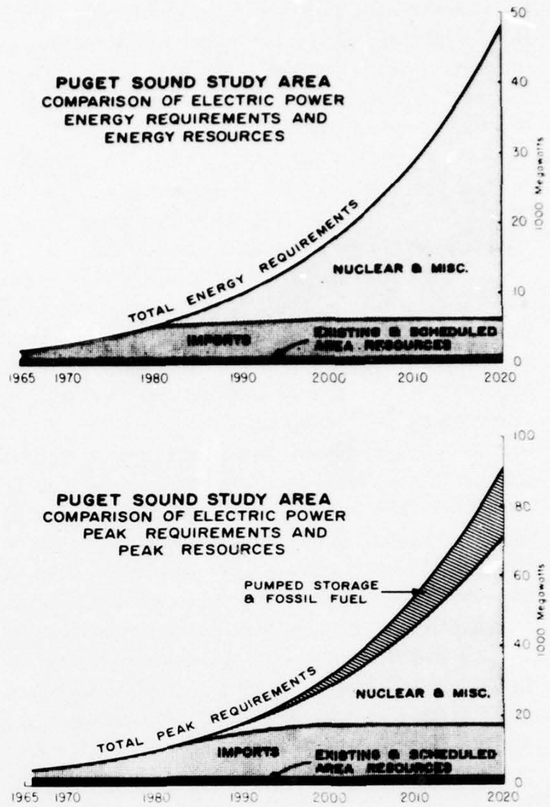


FIGURE 2-5. Electric power-energy and peaking requirements, Puget Sound Area

environment. Some, or even all of the base-load thermal nuclear generation could be located within the Area itself. Having the power plants located within the Area would result in minimizing transmission costs. However, due to environmental considerations, some thermal base-load plants may be near the Ocean or east of the Cascade Mountains.

Many existing hydroelectric power plants in the Puget Sound Area are now operating as peaking plants. Others, however, are too old or too small to justify additional units for peaking purposes. Thus, there probably would be no significant change in the operation of most existing Area hydroelectric plants. However, the Skagit River system does represent a potential source of additional peaking capacity. The existing power production of the Skagit River system can be increased by raising Ross Dam, installing additional generating units at Diablo and Gorge Dams and constructing a reregulating dam at Copper Creek.

Eighty-nine potential hydroelectric sites with a total installed capacity of 3,390 mw were investigated. The results of the investigation revealed that no site approaches economic justification from a single-purpose standpoint.

During the study, the potential of pumped-storage was investigated at more than 100 sites in the Puget Sound Area. In the northern Cascade Mountains, there are an unusually large number of excellent pumped-storage sites. With off-peak thermal generation available for pumping energy, pumped-storage is potentially the most economical source of peaking capacity once the conventional hydroelectric capability of the Area are fully developed. Additional site investigation is required.

The Puget Sound Area, with a peak electric load of about 3,500 mw, presently imports about 2,000 mw. The importation of electric energy is at about the same ratio, two-thirds of requirements being met from outside sources. This importation is expected to continue as long as electrical generation is available from areas outside the Puget Sound Area.

Included in the early action portion of the Comprehensive Plan is hydroelectric power development as part of the North Fork Snoqualmie River project. Raising of Ross Dam on the Skagit River to provide increased power output from generating facilities at Ross, Gorge and Diablo Dams is recommended for further consideration to meet the Area's power needs. The importation of electric peaking capacity and energy from east of the Cascade Mountains would continue to increase through the 1990's until the Columbia River hydroelectric system is completely developed. Importation of 13,400 mw peaking capacity and 5,000 mw average energy would thereafter remain the same. The existing and development under consideration would meet the 1980 demand projected for the Puget Sound Area. However, by the year 2000, the Puget Sound Area would need additional generation of 13,490 mw of peaking capacity and 10,380 average mw of energy. The means for satisfying this additional demand would primarily be base-load thermal installations. Nuclear power plants are scheduled to supply 12,100 mw peaking capacity with 10,300 mw of energy. Pumped-storage power plants that satisfactorily meet environmental considerations may be provided to assist in supplying peaking capacity. Some fossil-fuel plants in the form of gas turbines may also be installed in the future at locations near load centers to assist in meeting peak power demands.

Installation of about 52,000 mw of nuclear power generation would be required by the year 2020. The Puget Sound Area has many features advantageous to nuclear power plants siting, these include: (1) a plentiful supply of cold water for cooling purposes, (2) favorable tidal currents at many locations conducive to rapid dispersal of cooling water, (3) protected deep water, close to shore, providing good access by sea, and (4) proximity to major load centers and major transmission facilities. However, around Puget Sound there are some siting problems that stem from growing high-density populations and in some cases restricted mixing in the waters of the Sound. Sites under active consideration for nuclear power plant development are Kiket and Samish Islands in the Skagit-Samish Basins, Cherry Point in the Nooksack-Sumas Basins, and Sequim in the Elwha-Dungeness Basins. These sites are under active study and investigation.

Power plants that would use once-through cooling systems, as envisioned for those in the Puget Sound Area, need a large water supply. The expected dissipitation heat rate from a 1,000 mw nuclear power plant would be about 1,600 cfs to limit the coolant temperature to maximum rise of 20°F. This type of cooling system fairly limits the potential thermal-nuclear plants to the use of salt water for cooling.

With once-through cooling each nuclear plant requires about 350 acres including about 6,000 lineal feet of water frontage. Hypothetically the total land requirements of fifty-two 1,000 mw plants with once-through cooling would be 18,200 acres including 59 miles of water frontage.

Capital and operating costs of nuclear plants determine whether they are economically competitive with other types of thermal power plants. Nuclear plants with the larger size units tend to cost less per kilowatt. In the period 1975-1980, new nuclear plants most likely would be composed of several units in the 750-1,500 mw range and would cost in the range of \$100 to \$200 per kilowatt. At the rate of \$200 per kilowatt, a 1,000 mw nuclear power plant would cost about \$200,000,000.

In the decade between now and 1980, over 7 billion dollars would be invested in electric power facilities in the Pacific Northwest. Of this total, about 2.7 billion dollars would be attributable to low voltage transmission and distribution, about 1.7 billion dollars to high-voltage transmission, about 1.6 billion dollars to hydro capacity, and, about 1.3 billion

dollars to thermal generation. In the next 10 years, from 1980 to 1990, about 9 billion dollars would be invested in electric power facilities in the region, of which 3.2 billion dollars would be in low-voltage transmission distribution, 1.2 billion dollars would be in high-voltage transmission, 1.9 billion dollars in additional hydro capacity, and 2.6 billion dollars in thermal generation facilities. Under past and present trends, about one-third of the investment is expected to be in the Puget Sound Area.

Flood Control

The Comprehensive Plan provides for the reduction of future flood damages associated with mainstem overbank flooding of urban and rural communities and agricultural lands in the flood plains of each of nine major river basins. The two island groups—San Juan and Whidbey-Camano Islands—do not have serious overbank flooding. Complementary measures of flood prevention and control are discussed under Watershed Management.

The objectives of flood protection adopted for this study would generally be met by a combination of management programs and flood control projects. All urban and industrial lands would have at least a 100-year level of protection, with the exception of a relatively small amount of land in the Snohomish River Basin above the town of Snohomish along the Pilchuck River. Prime agricultural lands with a high density of farm buildings and residences would be provided a 50-year level of protection. Other agricultural lands in all but the Skykomish River Basin would be provided with a 25-year level of protection. In that basin levees or storage projects required to achieve a 25-year level of protection are neither economically justified at this time nor expected to be in the future. Flood plain management is an integral part of the Comprehensive Plan. Management and project costs to satisfy a significant amount of the Puget Sound Area flood control needs over the 50-year planning period are estimated to range from \$328,589,000 to \$381,589,000, averaging from \$6,600,000 to \$7,600,000 per year, depending on which alternative plan is selected.

The early action portion of the Comprehensive Plan requires an investment ranging from \$168,054,000 to \$176,054,000 to implement flood plain management programs, construct economically justified levees and channel improvements, and pay for the allocated flood control costs of multiple-purpose storage projects.

In the Nooksack-Sumas Basins a storage project would be constructed at the Edfro site on the North Fork Nooksack River. In the Skagit-Samish Basins levees would be raised, the operation of Upper Baker Dam changed, and the Avon Bypass constructed. The size of the bypass would depend on the alternative plan selected. In the Stillaguamish Basin levee and channel improvements would be constructed. In the Snohomish Basin multiple-purpose storage projects on the North and Middle Forks Snoqualmie River would be constructed, Culmback Dam on the Sultan River raised, and levee and channel improvements made along the lower Snohomish River. In the Cedar-Green Basins additional storage would be obtained at Chester Morse Lake on the Cedar River through construction of a low dam at the lake outlet. In the Puyallup Basin levees would be constructed to protect the town of Orting. In the Nisqually-Deschutes Basins the plan includes using storage at Alder Reservoir on the Nisqually River by agreement with the city of Tacoma. In the West Sound Basins a levee would be constructed along the Dosewallips River to protect the State park.

Flood plain management, including land use zoning, floodproofing and other regulations necessary to protect existing structures and prevent unwarranted development in the flood plains is an essential part of the Comprehensive Plan. Flood plain regulations would be utilized to establish and protect the required minimum channel for passage of flood flows and to control land use and development in those areas with less than 100-year level of flood protection. Flood plain zoning would also provide a means of retaining open space if supported by land use zoning.

Shown in Table 2-33 is a summary of flood control projects that would be implemented prior to 1980.

The long-range program for satisfying flood control needs includes development of additional storage in the Nooksack-Sumas Basins as part of the multiple-purpose North Fork project, and in the Skagit-Samish Basins with the Sauk River project, if found to be desirable after completion of the Wild and Scenic River Study in the Skagit Basin. Modification of the outlet works at the South Fork of the Tolt River project would provide additional flood control storage for the Snoqualmie River system in the Snohomish Basin. Storage projects are planned for construction on the Puyallup River prior to the year 2000 and on the Deschutes River after 2000.

TABLE 2-33. Flood control projects for main-stem overbank flooding, Puget Sound Area

	Levees						Channel Improvements						Storage Projects					
	By 1980		1980-2000		2000-2020		By 1980		1980-2000		2000-2020		By 1980		1980-2000		2000-2020	
Basins	No. of Projects	Miles	No. of Projects	Miles	No. of Projects	Miles	No. of Projects	Miles	No. of Projects	Miles	No. of Projects	Miles	No. of Projects	Ac. Ft.	No. of Projects	Ac. Ft.	No. of Projects	Ac. Ft.
Nooksack Sumas	1	6.0	3	20									1	63,000	1	21,000		
Skagit Samish																		
Alternative A	2	39.5	2	7			2[1]	10.8					1	100,000	1	134,000		
Alternative B	2	39.5	2	7			2[1]	10.8					1	100,000	0	0		
Stillaguamish	1	13.0	1	11			1	6.2										
Snohomish			6	13			2	11.5	1	3.3	1	3.7	3	270,000	1	15,000		
Cedar Green			1	13			1	16					1	50,000				
Puyallup	1	6.0	1	2											1	24,000		
Nisqually Deschutes																		
Alternative A			0	0					0	0			1	55,000			1	15,000
Alternative B			1	2					1	1			1	55,000			1	15,000
West Sound	1	0.3	2	6.1														
Elwha Dungeness					2	9.5												
Whidbey Camano Is.																		
San Juan Is.																		
Puget Sound Area																		
Alternative A	6	64.8	16	72.1	2	9.5	6	44.5	1	3.3	1	3.7	7	538,000	4	194,000	1	15,000
Alternative B	6	64.8	17	75.1	2	9.5	6	44.5	2	4.3	1	3.7	7	538,000	3	60,000	1	15,000

[1] Avon Bypass (8 miles) has been included with channel improvements.

Additional channel and levee projects would be undertaken in many of the basins in the long-range period to provide increased level of flood protection commensurate with the increase in urban and rural developments in the flood plains. Levees and channel improvements would be provided in the Nisqually River delta if port development is undertaken there. A change in operation of the existing dam on the Elwha River would be undertaken after 1980 to provide flood control protection in that basin. A total investment ranging from $152,535,000 to $213,535,000 is estimated to be required to provide the long-range flood control projects and flood plain management scheduled for the period 1980 to 2020, depending on which alternative plan is selected.

Watershed Management

The means provided in the Comprehensive Plan to achieve the objectives of watershed management include a wide spectrum of structural and nonstructural measures for development and improved use of the land and water resources. Structural measures are often the result of formal cost-sharing projects, while nonstructural land treatment and management measures are usually applied by the owner of the land under a planned program.

Nonstructural measures consist of land treatment and management operations for protection, rehabilitation and improvement of watershed lands and water flows originating thereon. Examples of rehabilitation and protection measures are fire protection, special precautions in road building to reduce hazard of resource damage, and construction activity modifications to reduce stream pollution by sediment. Development activities may be on-farm or urban water management measures installed to achieve known potentials, often made possible by structural projects. Many of these measures are on-going at the present time and would be a part of the planned program. Some elements of existing management is good, while others need substantial improvement and redirection. In future years with changed or more intensive use of watershed lands, the amounts of such measures would need to be greatly increased.

An important part of watershed management includes selection of watershed lands for specific development purposes in accordance with the capability of the land to sustain such use, coupled with adequate land treatment and water management based on the chosen use or combination of uses. The watershed area requiring management remains constant while the intensity of management increases with changed or more intense use of the land. Future development of the Area would require acceleration of management of land and water resources.

Projects, which are complementary to main-stem overbank flooding projects discussed under Flood Control, are generally multiple-purpose and designed to reduce damages caused by floodwater and sediment.

The watershed management programs and projects contained in the Comprehensive Plan to satisfy the Area's needs over the 50-year planning

period are estimated to cost $2,987,660,000 averaging $59,800,000 per year.

The early action program calls for the investment of $33,989,000 for projects planned under Public Law 566 for implementation prior to 1980, and $831,040,000 for complementary programs of land treatment, drainage, and erosion control. A 5-year study of beach and shore erosion is planned for initiation and completion by 1980 at an estimated cost of $500,000. This study would identify and evaluate areas where significant erosion is occurring, determine relevant factors for evaluation, describe justifiable remedial measures, and establish priorities for treatment.

Additional studies are needed in land management and its impacts on various environmental factors, such as the production and effects of sediment. Cooperative studies involving long-term measurement and evaluation of sediment production, movement, and impacts on various economic and ecologic factors are estimated at $2,250,000 for the early action period and $150,000 annually in the long-range period.

Completion of cooperative soil surveys on Area lands, updating of older inadequate surveys, and initiation of surveys of greater intensity in areas expected to become part of metropolitan developments is proposed. These surveys would be accelerated for guidance of development. This survey work, and reports included for early action, is estimated to cost $3,000,000.

A summary of principal measures for open lands is given in Tables 2-34 and 2-35. Urban water management, while often containing substantial structural work, is tabulated with nonstructural programs for convenience. Costs do not include sanitary sewage management shown under Water Quality Control.

Small watershed projects shown in Table 2-36 would aid in the prevention of floodwater damage to the lands at the small watershed level (areas of 250,000 acres or less) with 25 such projects planned for installation, or to be in progress by the year 1980, in addition to those already completed. Seven of the eleven basins are proposed for construction of small watershed projects. The Nooksack-Sumas Basins would have eight of the proposed projects, the Puyallup Basin five projects, and the Skagit-Samish Basins four projects. The remaining eight projects would be scattered in the Stillaguamish, Snohomish, Cedar and West Sound Basins.

The long-range planning for satisfying watershed management needs provides for further small watershed projects for flood prevention and a continuation of rehabilitation and protection programs and activities associated with development of land. A total investment of $2,171,280,000 is estimated to be required to satisfy the long-range watershed management needs from the period 1980 to 2020.

The long-range program features are shown in Table 2-34 and 2-35 and projects are indicated in Table 2-37.

TABLE 2-34. Summary of principal measures for watershed protection and management on cropland, Puget Sound Area

Treatment Measures	Unit	Early Action Program Appl. Cum. Through 1966[2]	Early Action Program 1980	Proposed for Installation 2000	Proposed for Installation 2020	Total
Erosion Control Measures						
Conservation cropping system	Acre	210,600	58,000	115,700	115,700	500,000
Pasture and hay land planting[1]	Acre	10,000	5,000	10,000	10,000	33,000
Cover crop[1]	Acre	24,000	28,800	57,500	57,500	167,800
Flood Prevention Measures						
Dike and levee	Feet	1,443,790	154,810	309,500	309,500	2,217,600
Clearing and snagging	Feet	211,500	380,460	760,020	760,080	2,112,000
Streambank protection	Feet	892,500	143,580	287,160	287,160	1,610,400
Stream channel improvement	Feet	459,580	76,960	153,930	153,930	844,400
Stream channel stabilization	Feet	25,350	17,110	34,210	34,210	110,880
Drainage Measures						
Drainage main or lateral	Feet	7,042,420	1,391,520	2,783,030	2,783,030	14,000,000
Drainage field ditch	Feet	81,470	2,152,710	4,305,410	4,305,410	10,845,000
Tile drain	Feet	5,790,860	11,133,240	22,266,450	22,266,450	61,457,000
Recreation Measures						
Recreation access road	Feet	1,105,350	444,210	888,420	888,420	3,326,400
Wildlife habitat management	Acre	107,180	192,940	385,850	385,850	1,071,820
Farm pond	Number	1,010	390	800	800	3,000

1 Conservation measures applied annually.

2 This includes accomplishments that are part of Soil Conservation Service Records System.

TABLE 2-35. Summary of principal measures for watershed protection and management on National Forests, Puget Sound Area

Treatment Measures	Unit	Early Action Program 1965-1980	Early Action Program Percent[1]	Proposed for Installation 1980-2000	Proposed for Installation 2000-2020
Managerial					
Surveys	Acres	8,875,970	95	5,048,170	0
Plans for watersheds	Numbers	87	100	41	0
Research studies[2]	Dollars	461,600	30	559,400	559,400
State and private programs[2]	Dollars	2,317,700	95	3,090,200	3,090,200
Protection					
Fire control	Acres	3,095,080	50	3,095,080	3,095,080
Insect and disease control[2,3]	Dollars	32,500	95	43,500	43,500
Road development					
Permanent	Miles	2,429	75	3,770	2,460
Temporary	Miles	9,432	60	16,810	20,705
Land use development					
Logging[5]	Acres	402,280	95	717,300	883,080
Grazing	Acres	11,720	75	33,020	64,600
Recreation[2]	Dollars	4,885,000	30	6,513,500	6,513,500
Restoration					
Reforestation	Acres	199,530	95	272,300	272,300
Gully stabilization	Miles	17.5	5	25	25
Erosion control	Acres	5,310	5	5,910	5,910
Channel clearance	Miles	83.7	10	150.3	150.3
Bank stabilization	Miles	143.4	5	156.5	156.5
Road and trail rehabilitation	Acres	150.2	5	206	206
Roadside stabilization	Acres	756	5	955	955
Water Yield Improvement[4]					
Cover-type conversion	Acres	0	0	40,750	40,450
Snowpack management facilities	Miles	0	0	810	798
Sediment basin construction	Acres	420	0	1,975	1,885
Flow regulation structures	Each	40	0	45	43
Water storage structures	Each	63	0	276	278
Wet land drainage structures	Each	2	0	8	0

1 Approximate percentage of needs met by current funding levels.

2 Based on allocation of total Regional program.

3 Costs include detection only.

4 Measures based on local determination of future off-site needs for water. These should be viewed as potential developments rather than specifically planned projects.

5 Area includes thinnings and release cuttings as well as harvest cuts.

TABLE 2-36. Early action watershed protection and management projects, Puget Sound Area

Basin and Watershed	Project Area (acres)	Channel Improvement (mi.)	Modification of Existing Protective Works (mi.)	Outlet Structures (no.)	Water Storage Facility (no.)	Debris Basin (no.)	Floodwater Protection (acres)	Drainage Improvement (acres)
NOOKSACK-SUMAS BASINS								
Middle Tribs. Nooksack	6,750	6.7	5.0	1			3,199	4,582
Fishtrap-Bertrand Cr.	23,914	37.0	6.0	2			13,159	13,508
Wiser Lake Area	38,305	29.0	10.1	4			14,791	18,832
Lower Nooksack Tribs.	19,835	18.9	9.3	5			10,499	12,559
Sumas River	33,079	22.0				1	14,509	14,692
Dakota Creek	20,314	18.0					593	3,118
California Creek	14,192	13.8			1		1,397	3,500
Silver Creek	10,855	16.0	5.0	1			2,736	4,999
Total	167,255	161.4	35.4	13	1	1	60,883	75,790
SKAGIT-SAMISH BASINS								
Gages Slough	14,419	17.0		1			9,520	7,087
South Mt. Vernon	32,132	21.5		4			9,619	10,501
Samish River	63,716	65.0		5			23,859	24,028
Skagit Flats	41,148	43.0	5.0	5			31,788	28,402
Total	151,415	146.5	5.0	15			74,786	70,018
STILLAGUAMISH BASIN								
Lower Stillaguamish	8,522	17.0	1.0	3			5,547	5,422
Church Creek	8,060	8.4	1.0	3			2,732	4,424
Total	16,582	25.4	2.0	6			8,279	9,846
SNOHOMISH BASIN								
Patterson Creek	12,451	8.0					667	1,426
Snohomish Estuary	29,759	15.0	11.0	3			12,321	10,222
Total	38,210	23.0	11.0	3			12,988	11,648
CEDAR BASIN								
Swamp, Bear, North Cr.	44,795	24.0		2			5,963	3,826
Evans Creek	29,800	16.0		2			3,348	3,620
Total	73,595	40.0		4			9,311	7,446
PUYALLUP BASIN								
Algona-Pacific	6,457	12.0					1,688	1,444
Clear Creek	8,060	21.0					2,364	6,587
Hylebos Creek	15,000	7.0		1			2,376	1,258
Wapato Creek	6,407	7.0		1			3,243	1,699
Clover Creek	58,092	14.0					4,990	805
Total	125,016	61.0		2			14,661	11,793
WEST SOUND BASINS								
Goldsborough Creek	38,501	5.0			1		3,388	261
Chimacum	22,326	16.0		8		1	3,375	2,717
Total	60,827	21.0		8	1	1	6,763	2,978
GRAND TOTAL	632,900	478.3	53.4	51	2	2	187,671	189,519

TABLE 2-37. Watershed management projects 1980-2020, Puget Sound Area

1980-2000			2000-2020		
Basin	Number of Projects	Total Installation Cost (dollars)	Basin	Number of Projects	Total Installation Cost (dollars)
Nooksack-Sumas	7	5,950,000	Nooksack-Sumas	5	936,000
Skagit-Samish	3	1,850,000	Skagit-Samish	5	1,460,000
Stillaguamish	3	5,620,000	Stillaguamish	3	1,310,000
Whidbey-Camano Is.	4	3,245,000	Whidbey-Camano Is.	0	0
Snohomish [1]	7	12,240,000	Snohomish	1	100,000
Cedar	3	3,810,000	Cedar	[illegible]	100,000
Green	1	1,700,000	Green	1	100,000
Puyallup	4	4,167,000	Puyallup	0	0
Nisqually	4	2,930,000	Nisqually	1	100,000
Deschutes	3	1,410,000	Deschutes	0	0
West Sound	12	8,055,000	West Sound	7	970,000
Elwha-Dungeness	5	2,962,000	Elwha-Dungeness	2	300,000
San Juan Is.	3	2,736,000	San Juan Is.	0	0
Total	59	56,675,000	Total	26	5,376,000

[1] Does not include Lake Stevens project installation cost of $147,000.

Recreation

In satisfying the future water-related recreation needs, the Comprehensive Plan sets forth a schedule of land acquisition and development providing for the timely construction of well-planned recreation facilities, the retention of public lands for recreational use, and the identification of natural areas which should be protected. The proposed recreation developments are intended to be in accordance with the Washington Statewide Outdoor Recreation and Open Space Plan.

The plan of development calls for an investment of $1,630,215,000 to acquire lands and develop recreation facilities during the 50-year period, averaging $32,600,000 per year. The plan includes $406,975,000 investment during the early action period. The land requirements for development including buffer zones are shown in the following tabulation:

	1980	2000	2020
Acres of development	9,500	12,200	21,800
Acres of buffer zones	8,200	10,500	18,700
Total acreage	17,700	22,700	40,500

The early action schedule proposes identifying, acquiring, and developing over 600 recreation areas. Priority is given to acquiring and developing salt water beaches, acquiring and providing access to public areas, designation of a system of scenic and recreation rivers, a program for setting aside unique, natural, archeological and historical sites, and the construction of facilities for campgrounds, picnic areas, beaches, swimming pools, boating areas and facilities including small boat harbors.

The early action needs can be met to a large degree by the expansion of existing facilities and development on public lands located within the Area. The Comprehensive Plan proposes that emphasis be given to the provision of access to waterfront lands adjacent to salt water, lakes, and major rivers within one hour's drive of urban areas. Examples are the Lake Washington Ship Canal trail, acquisition and development of the Magnolia tideflats, Everett to Edmonds beach trail, and the development of street ends as access to water areas such as Lake Union.

In the Skagit-Samish Basins, the Skagit River and some tributaries have high potential for inclusion in the National Wild River System. Prior to any determination of whether it should be included in the national system, future studies of its potential and expressions of national need must be made. These studies are scheduled for completion in 1973.

A major challenge to be met during the early

action period is the provision of public access along the shorelines of fresh and marine waters where developments have, to a great extent, shut off the public in many locations. The railroad tracks located along the marine shoreline from Everett to Seattle and other locations in Puget Sound restrict public use of the shoreline and access to the marine resource. The Plan proposes that access easements with road access and pedestrian crossings be acquired along the railroad right-of-way to provide for public use of the marine shoreline. The Plan recommends that additional studies by undertaken to determine the desirability and justification for opening the closed municipal watersheds for recreational use.

The Plan includes a network of scenic routes to provide travel links between recreation attractions used by a large segment of the population who enjoy driving for both pleasure and sightseeing. In addition, a network of trails are planned and scenic and recreation rivers are designated for possible inclusion as a part of a State-wide system.

The long-range program for satisfying recreation needs provides for expansion and development of additional recreation facilities and acquisition of lands at 918 recreation areas. A total investment of $1,223,240,000 is estimated to be required to satisfy the long-range recreation needs for the period 1980 to 2020.

Fish and Wildlife

The Comprehensive Plan sets forth a schedule of project and facility developments concurrent with program and management proposals to increase production and harvest of the fish and wildlife resources of the Puget Sound Area. The development schedule initially sets forth specific measures to acquire additional natural spawning, rearing, nesting, and forage habitat areas for greater natural propagation. This would be followed by construction and development of artificial measures such as hatcheries, spawning channels, and rearing ponds. Commensurate with these developmental measures would be water control measures to decrease flood flows, provide low flow augmentation, and prevent water pollution. Low flow augmentation in many of the rivers is considered one of the most important and best means of increasing anadromous and game fish production in the Puget Sound Area.

To insure fishing and hunter success, streambank, lake, and salt water access areas would be acquired and developed. Boat launching ramps, waterfowl observation and hunting facilities would be included in the access area developments.

The fish and wildlife projects and programs contained in the Comprehensive Plan for the 50-year period are estimated to range between $283,103,000 and $285,603,000 depending upon the alternative selected, including $3,018,000 for programs and projects on National Forest Lands. This would average about $5,700,000 per year. The National Forest projects would involve stream clearance, debris removal from lakes, and lake fertilization and game habitat improvement. These are included with other fish and wildlife projects in the Area discussion.

The early action plan requires an investment ranging from $62,703,000 to $65,203,000 ($1,061,000—National Forests) for projects planned to meet the 1980 level of needs, and $3,380,000 for complementary fish and wildlife programs, including $388,000 for an Area-wide program of stream surveys. The minimum streamflows necessary to maintain present fish production levels are unknown and would be determined from the cross-sectional stream surveys. Tentative minimum flows were provided in Appendix XI, Fish and Wildlife, for consideration in this study. However, these flows could not be supplied in any of the river basins on a sustained basis without significant carry-over storage. Consequently, planning proceeded on the basis of augmenting naturally occurring streamflows during critical low flow periods for fish to the extent possible, commensurate with other water resource needs. Further project studies would be required after the cross-sectional studies are completed.

Artificial trout, steelhead and salmon propagation facilities are planned for implementation prior to 1980 throughout the Puget Sound Area. These include 14 new trout and 1 new salmon hatchery, expansion of 3 existing trout and 4 existing salmon hatcheries, 2 miles of egg incubation or spawning channels and 55 controlled rearing areas for steelhead and cutthroat. The Plan contains 9 artificial passage facilitiest at natural and man-made barriers. Approximately 510 miles of stream access, 87 access sites on fresh water and 62 on salt water would be acquired and developed. Seven lake enlargements are planned and surveys would be conducted on 530 miles of stream and 5,270 surface acres of lakes. Multiple-purpose storage projects in the Nooksack, Snohomish and Cedar-Green Basins would provide for fishery enhancement through low flow augmentation and

control of floods that damage spawning beds through erosion and siltation.

Cross-sectional stream surveys are planned to determine minimum flows required to maintain current fish production levels and optimum flows for increased production. Also proposed for early action are fishing piers or jetties designed for use by sportsmen and located within or near the major metropolitan areas. The Plan contains proposals for increasing production of shellfish species for both commercial and sport use. Projects and programs are called for to protect the marine environment with particular emphasis on water quality, agriculture, and the preservation of natural beach and intertidal zones to maintain and enhance the shellfish production levels.

Wildlife and waterfowl projects for enhanced hunting opportunities include acquisition of 19,700 acres of waterfowl habitat and 3,000 acres of upland bird habitat. Expansion of pheasant farm facilities are planned to allow increased production of 37,300 birds annually. Big game habitat improvements are scheduled for 10,500 acres of Area lands.

Programs also are contained in the Comprehensive Plan for increasing the supply of fish and wildlife through basic research studies, especially those designed to develop new or improved management techniques. These include:

1. The development of lake and stream fertilization techniques which do not degrade water quality.

2. The development of new fish toxicants and lake and stream rehabilitation methods which do not degrade water quality.

3. The development of fish disease-control programs for lakes.

4. Making fish and wildlife population analysis and development of effective management programs.

5. Stimulation of interest in spiny-ray fishing.

6. Provide fisherman access to closed watersheds.

7. Expand range surveys and develop new habitat improvement techniques.

8. Develop cooperative programs with landowners to maintain, develop and assure hunter access.

The rapid development of the Puget Sound Area, with increasing urban and rural land transformation from farming and wood-covered areas, is projected as having a significant impact on wildlife. Based on the current trends of purchasing of hunting licenses, approximately 286,000 licensed hunters would reside in the Area by 1980. Meeting the future hunting needs depends upon the ability and the effort of the responsible management agenices, coupled with the mutually cooperative efforts of all entities interested in the protection and enhancement of wildlife habitat. Important elements of the wildlife program are those that deal with land management to improve the game carrying capacity of existing lands, with forest management playing an important role.

To maintain wildlife at the present level in the Area, a number of conditions must be met. These include the acquisition and development of suitable lands for public access, habitat improvement, artificial propagation for small game and birds, eventual use of the closed watersheds, and education of the public on the need for the preservation of the wildlife resource. Hunter success (game-kill per hunter-day) for 1980 is projected to decrease below present levels. To meet future needs, some hunters must leave the Area or be willing to accept a lower hunting success.

There are a number of sites which possess significant resource potential for waterfowl habitat development. These are Padilla Bay (Skagit-Samish Basins), Port Susan (Stillaguamish and Snohomish Basins), Nisqually Delta (Nisqually-Deschutes Basins), Samish Bay (Skagit-Samish Basins), and Ebey Island (Snohomish Basin). There are approximately a total of 4,000 acres that could serve as refuge areas.

The 3,000-acre Nisqually Delta is the last remaining significant river delta waterfowl habitat area between the Skagit Bay and the Columbia River. Development of 1,300 acres of the delta for navigation and related purposes would require a reduction in the waterfowl-recreational development plan presently being undertaken by the State of Washington which includes the full 3,000 acres. If part of the delta is developed for navigational uses, the natural waterfowl-recreational potential may not be met. Although the Comprehensive Plan does not determine the best use or uses of the Nisqually Delta, the Plan does provide for a multi-discipline study to be undertaken during the early action period to determine whether port development in the delta can or should be undertaken, compatible with wildlife and recreation use.

The long-range program for satisfying the fish and wildlife needs in the Puget Sound Area provides for construction of 44 hatcheries, 18 miles of spawning channels, habitat improvement on 114 streams, passage over 22 barriers, in excess of 670 acres rearing ponds as well as land measures designed

to increase wildlife production. A total investment of $217,020,000 ($1,957,000–National Forests) is estimated to be required to satisfy the long-range fish and wildlife needs for the period 1980 to 2020.

Estuaries and Coastal Zones

The management of the sea coast, estuaries and related shorelands of Puget Sound and adjacent waters is concerned with the use and care of natural resource values and productivity. These waters and related land constitute one of the Puget Sound Area's most valuable geographic features.

The marine resource includes wide physical diversities ranging from rugged shorelands, with many indentations, islands and rocks to smooth coastlines with few offshore features. Sandy beaches, rocky headlands, marshlands and river estuarial areas are located here. Water depths may slope gently from the shoreline or decline precipitously to depths of 800 feet or more.

Each of the shoreline areas and estuaries have a potential for satisfying various uses. Historically, the estuaries have been the basis for social and economic development.

The pressures for shoreline space and water surface use have increased rapidly in recent years and expected to accelerate. Coordinated efforts by Federal, State and local government and the private sector are required in order to provide for the best use of this resource. The estuaries of many of the rivers that flow into Puget Sound have been altered. The Sound itself remains relatively unaffected. The estuaries are important as they contribute to salmon, steelhead and shellfish production and provide waterfowl habitat. Taken together the many streams of the Puget Sound Area significantly contribute to the wealth of the Area in terms of fish and wildlife, recreation and aesthetics. Several large estuaries remain relatively undeveloped, these are the Nisqually and Skagit River deltas. Details on the possible use of these areas and the other elements in the Comprehensive Plan for management and control of the estuaries and coastal zones are given in previous pages.

The Comprehensive Plan includes the following provisions for the management and control of estuaries and coastal zones:

Water quality measures of waste treatment by municipalities and industry and construction of marine outfalls and diffusers to properly disperse treated wastes; an expanded water quality surveillance program to insure compliance with State standards which protect the estuaries.

Recreational development along the marine shoreline to enable public access to the salt water with retention of all lands now in public ownership; priority, for acquiring and developing salt water beaches and pedestrian crossings along the railroad right-of-way which follows the shoreline of Puget Sound from Seattle to Everett.

Preservation of the estuaries and protection of the marine waters in order to successfully provide continued opportunities for fishing and hunting; acquisition of marine shorelands for habitat as well as access.

A study to identify specific erosion sites and determine correction measures, as erosion of the shoreline not only destroys developments and adjacent properties but contributes to deposition and silt in the estuaries.

Finally, a coordinated program for future sea coast resource use to include:

1. A detailed appraisal of the present and potential resource.

2. A determination of opportunities for multiple use and enhancement of natural potential.

3. Analysis of the significance of natural and man-caused environmental variations.

4. Identification for reservation of selected unique water and related land elements.

5. Development of management guidelines for future use of the coastal resource.

6. Identification of research needs, development of units of measurement and prediction techniques.

INVESTMENT COSTS OF COMPREHENSIVE PLAN

A distribution of program and project investment costs for the Comprehensive Plan for the Puget Sound Area are shown in Tables 2-38 to 2-43. Cost distributions shown are only approximations. The largest investments in the Plan are for watershed management, recreation, water quality, and municipal and industrial water supply features.

The Federal watershed management costs on private lands are related to the project measures and

programs which offer technical or other assistance, while the private and State costs are for program measures. All costs on public lands are borne by the management agency. Program measures refer to on-farm, forest management, and urban on-site practices which take advantage of improvements made possible by the structural works of improvement, as well as measures for watershed protection, erosion control, and water management. Estimated costs include on-going protection and management costs as well as necessary acceleration. These measures would include seeding of improved grasses and legumes, cover crops, cropland and urban drainage control works and facilities, and forest management practices.

The recreation costs include all of the costs for water-related recreational development to satisfy the projected recreational needs. The costs are borne by Federal, State, and local government, and private enterprise. The costs are for land acquisition and facility development at campgrounds and picnic areas, swimming pools, beach acquisition and development, small boat basins, and the planning and design for these developments. The Federal costs are identified with developments at Federal recreation areas and in grants for recreation development to State and local governments. The State costs are for recreational development at State parks, on State lands, and in grants to local governments for recreational development. The local government costs include county and municipal parks, playgrounds, swimming, hiking, trails, access areas, boat launching ramps, scenic areas, and small boat basins. The private costs include fishing resorts, hunting areas, boat launching ramps, moorages, camping and picnic areas, etc. As the local and private recreational facilities are more numerous, and recreational use more widespread, they have been historically, and are, projected to provide the largest share of the investment.

The water quality costs include treatment facilities, sanitary sewers, monitoring, evaluation, control, and planning and design costs. The treatment facilities costs and sewers are generally borne by the local municipal governments and by private industry with additional funding provided by grants from the Federal and State governments.

The greatest future investment in water quality costs are for industrial and municipal treatment and sewage collection facilities. The largest costs would be for the State and local sectors. State costs are for grants to local governments and for surveillance programs. Industry costs for treatment are shown separately as private costs, with industrial sewers contained in the local costs since many industries discharge into municipal sewer systems. Local government costs shown would be reduced by Federal grants. The amount of these grants has not been estimated.

The municipal and industrial water supply costs include facilities for storing, diverting, and transmitting water by the purveyor. The costs do not include distribution systems within the municipality, rural community systems, or industry. As water supply systems costs are borne by the local government, water district, or individual, they have been nearly all assigned to the local sector. The Federal costs for grants in aid to the local sector for construction of municipal water supply systems have not been estimated.

Most irrigation development is expected to be accomplished through private development by the individual farmer and the costs have been distributed accordingly.

The navigation costs are for channel improvements. The cost sharing between local and Federal varies according to the degree project benefits are general in nature. Port District costs are included in the local sector.

Flood control costs vary with the type of project and include as local costs for levee and channel improvements the acquisition of right-of-way, modification to transportation facilities, and relocation of utilities. Remaining costs are borne by the Federal Government, assuming the improvement is a Federal project. For multiple-purpose storage projects the Federal Government bears all costs allocated to flood control.

Fish and wildlife enhancement costs would be borne primarily by State with some Federal contribution. Where anadromous fishery benefits are part of a federally constructed multiple-purpose storage project, the allocated project cost to fishery enhancement would be borne by the Federal Government.

A more detailed determination of program and project cost-sharing would be made during authorization studies.

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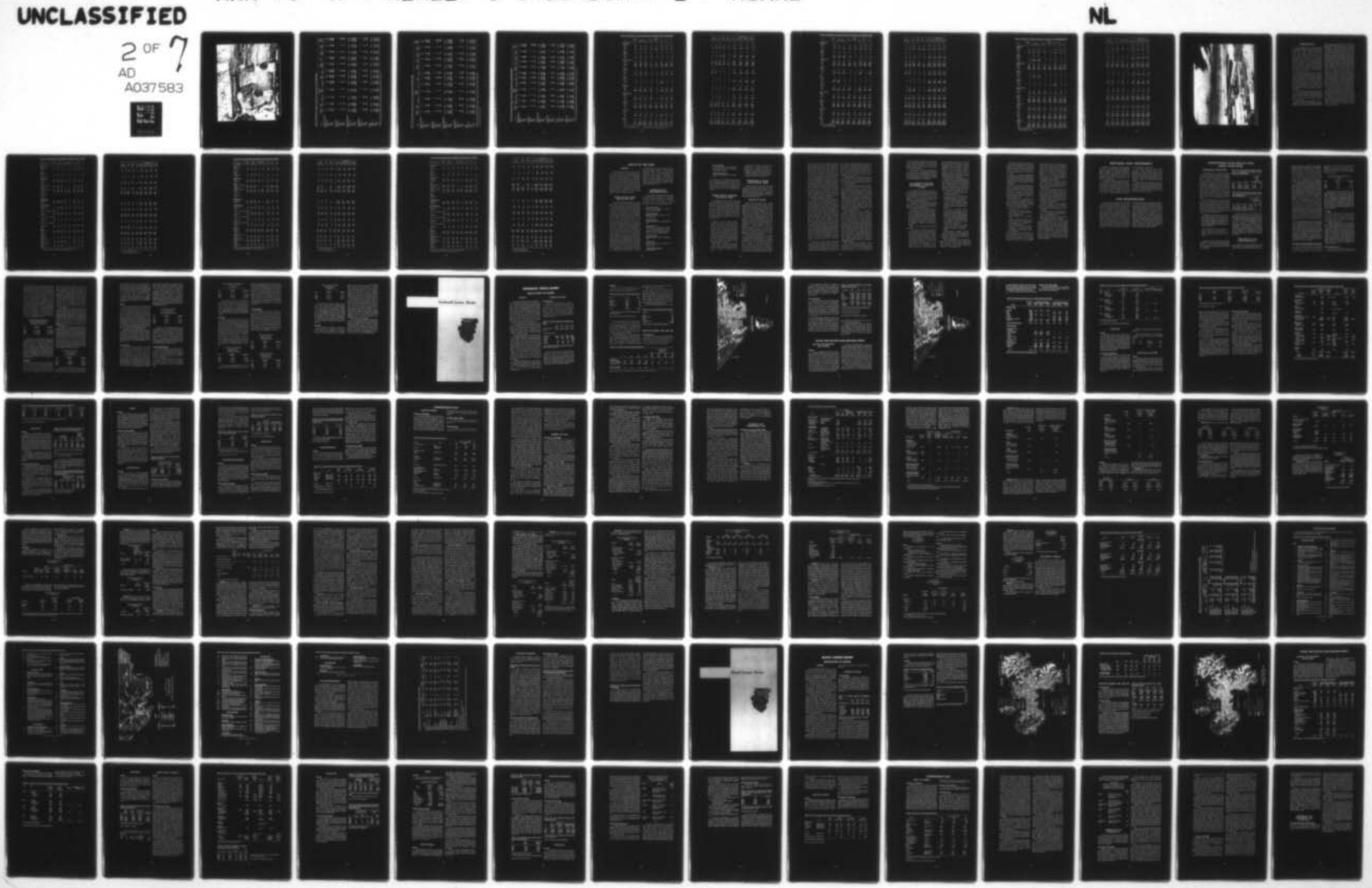
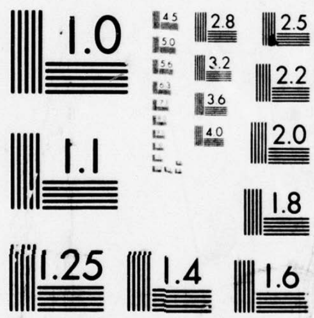




MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

PHOTO 2-25. Trout fishing during family outing on Puget Sound Area river. Washington State Department of Game Photo

TABLE 2-38. Distribution of program investment costs, Puget Sound Area 1970-1980 ($1000)

Feature	Nooksack-Sumas	Skagit-Samish	Stillaguamish	Whidbey-Camano Islands	Snohomish	Cedar-Green	Puyallup	Nisqually-Deschutes	West Sound	Elwha-Dungeness	San Juan Islands	Puget Sound Area
Water Quality Control												
Private	140	83	28	45	486	580	420	55	95	55	55	2,042
Government												
Local	140	83	28	45	486	580	420	55	95	55	55	2,042
State	373	226	73	110	1,003	1,570	1,230	165	380	165	170	5,465
Federal	187	98	31	50	425	670	530	75	180	75	60	2,381
Total	840	490	160	250	2,400	3,400	2,600	350	750	350	340	11,930
Flood Control												
Private	0	0	0	0	0	0	0	0	0	0	0	0
Government												
Local	32	90	19	0	38	84	130	57	87	22	0	559
State	9	17	4	0	11	24	37	16	25	6	0	149
Federal	5	8	2	0	6	39	18	9	13	3	0	103
Total	46	115	25	0	55	147	185	82	125	31	0	811
Watershed Management[1]												
Private	41,455	42,685	14,709	9,050	54,351	113,160	71,177	23,024	45,563	6,205	6,107	427,486
Government												
Local	4,410	7,988	3,301	5,267	28,640	98,881	53,403	8,957	23,590	2,471	2,676	239,584
State	3,721	4,888	3,248	832	5,050	1,095	553	2,875	8,282	2,139	980	33,663
Federal	10,946	31,995	7,435	1,117	20,463	12,818	10,539	5,854	19,969	7,037	2,134	130,307
Total	60,532	87,556	28,693	16,266	108,504	225,954	135,672	40,710	97,404	17,852	11,897	831,040
Fish and Wildlife												
Private	0	0	0	0	0	0	0	0	0	0	0	0
Government												
Local	0	0	0	0	0	0	0	0	0	0	0	0
State	488	253	160	15	450	440	403	127	465	176	15	2,992
Federal	0	0	0	0	0	0	0	0	0	0	0	0
Total	488	253	160	15	450	440	403	127	465	176	15	2,992
TOTAL												
Private	41,595	42,768	14,737	9,095	54,837	113,740	71,597	23,079	45,658	6,260	6,162	429,528
Government												
Local	4,582	8,161	3,348	5,312	29,164	99,545	53,953	9,069	23,772	2,548	2,731	242,185
State	4,591	5,384	3,485	957	6,514	3,129	2,223	3,183	9,152	2,486	1,165	42,269
Federal	11,138	32,101	7,468	1,167	20,894	13,527	11,087	5,938	20,162	7,115	2,194	132,791
Total	61,906	88,414	29,038	16,531	111,409	229,941	138,860	41,269	98,744	18,409	12,252	846,773

[1] Does not include operation and maintenance costs or other program costs estimated on an Area basis only.

TABLE 2-39. Distribution of program investment costs, Puget Sound Area 1980-2000 ($1000)

Feature	Nooksack-Sumas	Skagit-Samish	Stillaguamish	Whidbey-Camano Islands	Snohomish	Cedar-Green	Puyallup	Nisqually-Deschutes	West Sound	Elwha-Dungeness	San Juan Islands	Puget Sound Area
Water Quality Control												
Private	171	64	42	32	920	812	660	48	60	68	24	2,901
Government												
Local	171	64	42	32	920	812	660	48	60	68	24	2,901
State	264	164	150	94	480	2,252	2,020	104	168	210	76	5,982
Federal	104	68	66	40	192	860	860	40	72	94	36	2,538
Total	710	360	300	200	2,512	4,840	4,200	240	360	440	160	14,322
Flood Control												
Private	0	0	0	0	0	0	0	0	0	0	0	0
Government												
Local	65	117	32	0	70	168	70	80	70	14	0	686
State	18	34	9	0	20	48	20	23	20	4	0	196
Federal	9	17	5	0	10	24	10	11	10	2	0	98
Total	92	168	46	0	100	240	100	114	100	20	0	980
Watershed Management [1]												
Private	47,794	43,765	14,339	10,629	58,564	112,147	47,186	35,578	53,392	6,258	7,125	436,777
Government												
Local	5,351	6,554	919	5,050	26,225	94,955	26,432	17,394	22,634	2,401	2,550	210,465
State	4,961	6,517	4,331	1,109	6,733	1,460	737	3,833	11,042	2,851	1,308	44,882
Federal	12,283	42,390	9,891	1,624	42,705	21,739	19,768	11,326	34,634	11,719	3,006	211,085
Total	70,389	99,226	29,480	18,412	134,227 [2]	230,301	94,123	68,131	121,702	23,229	13,989	903,209
Fish and Wildlife												
Private	0	0	0	0	0	0	0	0	0	0	0	0
Government												
Local	0	0	0	0	0	0	0	0	0	0	0	0
State	430	200	320	15	750	602	630	478	800	309	0	4,534
Federal	0	0	0	0	0	0	0	0	0	0	0	0
Total	430	200	320	15	750	602	630	478	800	309	0	4,534
TOTAL												
Private	47,965	43,829	14,381	10,661	59,484	112,959	47,846	35,626	53,452	6,326	7,149	439,678
Government												
Local	5,587	6,735	993	5,082	27,215	95,935	27,162	17,522	22,764	2,483	2,574	214,052
State	5,673	6,915	4,810	1,218	7,983	4,362	3,407	4,438	12,030	3,374	1,384	55,594
Federal	12,396	42,475	9,962	1,666	42,907	22,727	20,638	11,377	34,716	11,815	3,042	213,721
Total	71,621	99,954	30,146	18,627	137,589	235,983	99,053	68,963	122,962	23,998	14,149	923,045

[1] Does not include operation and maintenance costs or other program costs estimated on an Area basis only.

[2] Includes cost of Lake Stevens project.

TABLE 2-40. Distribution of program investment costs, Puget Sound Area 2000-2020 ($1000)

Feature	Nooksack-Sumas	Skagit-Samish	Stillaguamish	Whidbey-Camano Islands	Snohomish	Cedar-Green	Puyallup	Nisqually-Deschutes	West Sound	Elwha-Dungeness	San Juan Islands	Puget Sound Area
Water Quality Control												
Private	187	70	54	40	284	892	840	48	80	84	28	2,607
Government												
Local	187	70	54	40	284	892	840	48	80	84	28	2,607
State	298	196	162	112	600	2,476	2,460	132	224	244	100	7,004
Federal	118	84	70	48	232	1,060	960	58	96	108	44	2,878
Total	740	420	340	240	1,400	5,320	5,100	286	480	520	200	15,096
Flood Control												
Private	0	0	0	0	0	0	0	0	0	0	0	0
Government												
Local	65	117	32	0	70	168	70	80	70	14	0	686
State	18	34	9	0	20	48	20	23	20	4	0	196
Federal	9	17	5	0	10	24	10	11	10	2	0	98
Total	92	168	46	0	100	240	100	114	100	20	0	980
Watershed Management [1]												
Private	41,761	58,554	14,160	11,497	56,729	111,252	67,395	19,165	49,774	6,829	6,740	443,856
Government												
Local	7,538	7,244	1,948	5,483	29,236	96,548	50,568	586	22,526	2,543	2,801	227,021
State	4,961	6,517	4,331	1,109	6,733	1,460	737	3,833	11,042	2,851	1,308	44,882
Federal	11,113	37,003	8,108	1,553	42,842	20,784	19,564	10,922	37,274	12,214	2,871	204,248
Total	65,373	109,318	28,547	19,642	135,540	230,044	138,264	34,506	120,616	24,437	13,720	920,007
Fish and Wildlife												
Private	0	0	0	0	0	0	0	0	0	0	0	0
Government												
Local	0	0	0	0	0	0	0	0	0	0	0	0
State	435	200	320	15	750	776	630	470	800	300	0	4,696
Federal	0	0	0	0	0	0	0	0	0	0	0	0
Total	435	200	320	15	750	776	630	470	800	300	0	4,696
TOTAL												
Private	41,948	58,624	14,214	11,537	57,013	112,144	68,235	19,213	49,854	6,913	6,768	446,463
Government												
Local	7,790	7,431	2,034	5,523	29,590	97,608	51,478	714	22,676	2,641	2,829	230,314
State	5,712	6,947	4,822	1,236	8,103	4,760	3,847	4,458	12,086	3,399	1,408	56,778
Federal	11,240	37,104	8,183	1,601	43,084	21,868	20,534	10,991	37,380	12,324	2,915	207,224
Total	66,690	110,106	29,253	19,897	137,790	236,380	144,094	35,376	121,996	25,277	13,920	940,779
GRAND TOTAL												
Private	131,508	145,221	43,332	31,293	171,334	338,843	187,678	77,918	148,964	19,499	20,079	1,315,669
Government												
Local	17,959	22,327	6,375	15,917	85,969	293,088	132,593	27,305	69,212	7,672	8,134	686,551
State	15,976	19,246	13,117	3,411	22,600	12,251	9,477	12,079	33,268	9,259	3,957	154,641
Federal	34,774	111,680	25,613	4,434	106,885	58,122	52,259	28,306	92,258	31,254	8,151	553,736
Total	200,217	298,474	88,437	55,055	336,788	702,304	382,007	145,608	343,702	67,684	40,321	2,710,597

[1] Does not include operation and maintenance costs or other program costs estimated on an Area basis only.

TABLE 2-41. Distribution of project investment costs, Puget Sound Area 1970-1980 ($1000)

Feature	Nooksack-Sumas	Skagit-Samish Alt. A[1]	Skagit-Samish Alt. B[2]	Stillaguamish	Whidbey-Camano Islands	Snohomish	Cedar-Green	Puyallup
M&I Water Supply								
Private	2,730	0	0	0	0	900	2,704	660
Government								
Local	8,459	5,440	5,440	564	10,316	34,821	19,000	41,403
State	0	0	0	0	0	0	0	0
Federal	0	0	0	0	0	0	0	0
Total	11,189	5,440	5,440	564	10,316	35,721	21,704	42,063
Irrigation								
Private	2,700	1,350	1,350	540	0	825	0	340
Government								
Local	0	0	0	0	0	0	0	0
State	0	0	0	0	0	0	0	0
Federal	0	0	0	0	0	0	0	0
Total	2,700	1,350	1,350	540	0	825	0	340
Water Quality Control								
Private	10,260	2,400	2,400	670	0	85,230	0	5,600
Government								
Local	2,020	1,000	1,000	370	1,379	5,645	55,500	13,300
State	1,010	500	500	185	689	2,823	27,750	6,650
Federal	2,510	980	980	635	1,119	3,692	30,600	8,450
Total	15,800	4,880	4,880	1,860	3,187	97,390	113,850	34,000
Navigation								
Private	0	0	0	0	0	0	0	0
Government								
Local	210	426	426	0	0	1,043	2,212	2,084
State	0	0	0	0	0	0	0	0
Federal	457	1,039	1,039	0	0	1,157	1,567	3,346
Total	667	1,465	1,465	0	0	2,200	3,779	5,430
Power[3]								
Private	0	0	0	0	0	0	0	0
Government								
Local	0	0	0	0	0	0	0	0
State	0	0	0	0	0	0	0	0
Federal	0	0	0	0	0	32,845	0	0
Total	0	0	0	0	0	32,845	0	0
Flood Control								
Private	0	0	0	0	0	0	0	0
Government								
Local	250	5,660	7,060	800	0	3,195	1,200	160
State	0	0	0	0	0	0	0	0
Federal	25,185	32,140	38,740	6,900	0	74,623	15,540	1,440
Total	25,435	37,800	45,800	7,700	0	77,818	16,740	1,600
Watershed Management								
Private	0	0	0	0	0	0	0	0
Government								
Local	3,292	3,412	3,412	496	0	621	654	1,947
State	0	0	0	0	0	0	0	0
Federal	7,681	7,225	7,225	1,149	0	1,882	1,526	3,025
Total	10,973	10,637	10,637	1,645	0	2,503	2,180	4,972
Recreation								
Private	5,458	7,163	7,163	3,063	7,100	12,180	16,328	8,847
Government								
Local	9,551	10,744	10,744	6,126	7,100	24,104	24,490	12,386
State	6,822	7,163	7,163	7,147	11,405	12,180	10,885	7,078
Federal	5,458	10,744	10,744	4,084	2,845	49,078	2,722	7,078
Total	27,289	35,814	35,814	20,420	28,450	97,542	54,425	35,389
Fish and Wildlife								
Private	0	0	0	0	0	0	0	0
Government								
Local	0	0	0	0	0	0	0	0
State	3,455	11,799	11,799	5,220	577	8,797	5,067	3,132
Federal	242	0	0	0	0	10,140	870	174
Total	3,697	11,799	11,799	5,220	577	18,937	5,937	3,306
TOTAL								
Private	21,148	10,913	10,913	4,273	7,100	26,635	19,032	15,447
Government								
Local	23,782	26,682	28,082	8,356	18,795	69,429	103,056	71,280
State	11,287	19,462	19,462	12,552	12,671	23,800	43,702	16,860
Federal	41,533	52,128	58,728	12,768	3,964	173,417	52,825	23,513
Total	$97,750	$109,185	$117,185	$37,949	$42,530	$365,781	$218,615	$127,100

[1] Alternative A - Skagit-Samish Basins.
[2] Alternative A - Nisqually-Deschutes Basins.
[3] Power investments represent hydroelectric costs only. Not shown are nuclear power and fossil-fuel fired plant or pumped-storage facilities costs.

Nisqually-Deschutes		West Sound	Elwha-Dungeness	San Juan Islands	Puget Sound Area			
Alt. A	Alt. B				Alt. A–S.S.[1] Alt. A–N.D.[2]	Alt. A–S.S. Alt. B–N.D.	Alt. B–S.S. Alt. A–N.D.	Alt. B–S.S. Alt. B–N.D.
0	0	2,190	0	0	9,184	9,184	9,184	9,184
1,290	1,290	6,130	1,464	670	129,557	129,557	129,557	129,557
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
1,290	1,290	8,320	1,464	670	138,741	138,741	138,741	138,741
300	300	50	770	0	6,875	6,875	6,875	6,875
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	14,610	0	14,610	14,610	14,610	14,610
300	300	50	15,380	0	21,485	21,485	21,485	21,485
775	775	2,300	9,870	225	117,330	117,330	117,330	117,330
1,850	1,850	3,700	1,600	186	86,550	86,550	86,550	86,550
925	925	1,850	800	94	43,276	43,276	43,276	43,276
1,825	1,825	3,050	1,325	1,319	55,505	55,505	55,505	55,505
5,375	5,375	10,900	13,595	1,824	302,661	302,661	302,661	302,661
0	0	0	0	0	0	0	0	0
891	891	0	0	0	6,866	6,866	6,866	6,866
0	0	0	0	0	0	0	0	0
962	962	0	0	0	8,528	8,528	8,528	8,528
1,853	1,853	0	0	0	15,394	15,394	15,394	15,394
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	32,845	32,845	32,845	32,845
0	0	0	0	0	32,845	32,845	32,845	32,845
0	0	0	0	0	0	0	0	0
0	0	15	0	0	11,280	11,280	12,680	12,680
0	0	0	0	0	0	0	0	0
0	0	135	0	0	155,963	155,963	162,563	162,563
0	0	150	0	0	167,243	167,243	175,243	175,243
0	0	0	0	0	0	0	0	0
0	0	343	0	0	10,765	10,765	10,765	10,765
0	0	0	0	0	0	0	0	0
0	0	736	0	0	23,224	23,224	23,224	23,224
0	0	1,079	0	0	33,989	33,989	33,989	33,989
4,400	4,400	15,553	1,652	3,806	85,550	85,550	85,550	85,550
7,680	7,680	18,664	2,066	3,045	125,956	125,956	125,956	125,956
5,471	5,471	21,774	2,889	7,612	100,426	100,426	100,426	100,426
4,400	4,400	6,221	1,652	761	95,043	95,043	95,043	95,043
21,951	21,951	62,212	8,259	15,224	406,975	406,975	406,975	406,975
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
5,051	2,551	6,284	2,749	585	52,716	50,216	52,716	50,216
0	0	0	0	0	11,426	11,426	11,426	11,426
5,051	2,551	6,284	2,749	585	64,142	61,642	64,142	61,642
5,475	5,475	20,093	12,292	4,031	218,939	218,939	218,939	218,939
11,711	11,711	28,852	5,130	3,901	370,974	370,974	370,974	370,974
11,447	8,947	29,908	6,438	8,291	196,418	193,918	196,418	193,918
7,187	7,187	10,142	17,587	2,080	397,144	397,144	403,744	403,744
$35,820	$33,320	$88,995	$41,447	$18,303	$1,183,475	$1,180,975	$1,191,475	$1,188,975

TABLE 2-42. Distribution of project investment costs, Puget Sound Area 1980-2000 ($1000)

Feature	Nooksack-Sumas	Skagit-Samish Alt. A	Skagit-Samish Alt. B	Stillaguamish	Whidbey-Camano Islands	Snohomish	Cedar-Green	Puyallup
M&I Water Supply								
Private	1,640	0	0	0	0	650	10,140	900
Government								
Local	7,437	8,125	8,125	858	2,500	63,732	64,380	35,616
State	0	0	0	0	0	0	0	0
Federal	0	0	0	0	0	0	0	0
Total	9,077	8,125	8,125	858	2,500	64,382	74,520	36,516
Irrigation								
Private	11,120	1,100	1,100	540	0	527	55	680
Government								
Local	0	0	0	0	0	0	0	0
State	0	0	0	0	0	0	0	0
Federal	11,120	6,000	6,000	0	0	0	0	0
Total	22,240	7,100	7,100	540	0	527	55	680
Water Quality Control								
Private	6,950	2,650	2,650	830	0	10,300	0	7,200
Government								
Local	5,040	2,250	2,250	772	3,555	9,790	135,000	20,800
State	2,520	1,125	1,125	386	1,778	4,895	67,500	10,400
Federal	4,520	2,025	2,025	1,306	2,777	7,495	73,300	12,800
Total	19,030	8,050	8,050	3,294	8,110	32,480	275,800	51,200
Navigation								
Private	0	0	0	0	0	0	0	0
Government								
Local	448	2,682	2,682	0	0	2,309	0	1,720
State	0	0	0	0	0	0	0	0
Federal	895	6,735	6,735	0	0	5,387	0	2,768
Total	1,343	9,417	9,417	0	0	7,696	0	4,488
Power								
Private	0	0	0	0	0	0	0	0
Government								
Local	0	0	0	0	0	0	0	0
State	0	0	0	0	0	0	0	0
Federal	20,000	68,000	0	0	0	0	0	0
Total	20,000	68,000	0	0	0	0	0	0
Flood Control								
Private	0	0	0	0	0	0	0	0
Government								
Local	1,000	580	780	400	0	3,787	130	100
State	0	0	0	0	0	0	0	0
Federal	25,760	65,220	7,020	3,300	0	36,083	1,170	27,400
Total	26,760	65,800	7,800	3,700	0	39,870	1,300	27,500
Watershed Management								
Private	0	0	0	0	0	0	0	0
Government								
Local	1,785	592	592	1,694	1,136	3,051	1,653	1,625
State	0	0	0	0	0	0	0	0
Federal	4,165	1,258	1,258	3,926	2,109	9,336	3,857	2,542
Total	5,950	1,850	1,850	5,620	3,245	12,387	5,510	4,167
Recreation								
Private	5,440	8,540	8,540	3,120	7,950	13,900	21,000	13,900
Government								
Local	9,520	12,810	12,810	6,240	7,950	20,850	31,500	19,460
State	6,800	8,540	8,540	7,280	12,720	13,900	14,000	11,120
Federal	5,440	12,810	12,810	4,160	3,180	20,850	3,500	11,120
Total	27,200	42,700	42,700	20,800	31,800	69,500	70,000	55,600
Fish and Wildlife								
Private	0	0	0	0	0	0	0	0
Government								
Local	0	0	0	0	0	0	0	0
State	11,067	18,909	18,909	5,568	528	12,294	7,916	7,629
Federal	100	0	0	0	0	0	0	410
Total	11,167	18,909	18,909	5,568	528	12,294	7,916	8,039
TOTAL								
Private	25,150	12,290	12,290	4,490	7,950	25,377	31,195	22,680
Government								
Local	25,230	27,039	27,239	9,964	15,141	103,519	232,663	79,321
State	20,387	28,574	28,574	13,234	15,026	31,089	89,416	29,149
Federal	72,000	162,048	35,848	12,692	8,066	79,151	81,827	57,040
Total	$142,767	$229,951	$103,951	$40,380	$46,183	$239,136	$435,101	$188,190

[1] Alternative A – Skagit-Samish Basins.

[2] Alternative A – Nisqually-Deschutes Basins.

Nisqually-Deschutes Alt. A	Nisqually-Deschutes Alt. B	West Sound	Elwha-Dungeness	San Juan Islands	Puget Sound Area: Alt. A–S.S.[1] Alt. A–N.D.[2]	Puget Sound Area: Alt. A–S.S. Alt. B–N.D.	Puget Sound Area: Alt. B–S.S. Alt. A–N.D.	Puget Sound Area: Alt. B–S.S. Alt. B–N.D.
0	0	1,280	0	0	14,610	14,610	14,610	14,610
435	435	16,910	2,678	10,200	212,871	212,871	212,871	212,871
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
435	435	18,190	2,678	10,200	227,481	227,481	227,481	227,481
680	680	70	0	0	14,772	14,772	14,772	14,772
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	17,120	17,120	17,120	17,120
680	680	70	0	0	31,892	31,892	31,892	31,892
1,960	1,960	4,400	7,340	0	41,630	41,630	41,630	41,630
1,550	1,550	8,300	560	134	187,751	187,751	187,751	187,751
775	775	4,150	280	67	93,876	93,876	93,876	93,876
2,475	2,475	8,450	1,580	2,767	119,495	119,495	119,495	119,495
6,760	6,760	25,300	9,760	2,968	442,752	442,752	442,752	442,752
0	0	0	0	0	0	0	0	0
1,784	2,984	0	0	0	8,943	10,143	8,943	10,143
0	0	0	0	0	0	0	0	0
1,929	3,129	0	0	0	17,714	18,914	17,714	18,914
3,713	6,113	0	0	0	26,657	29,057	26,657	29,057
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	88,000	88,000	20,000	20,000
0	0	0	0	0	88,000	88,000	20,000	20,000
0	0	0	0	0	0	0	0	0
0	300	114	0	0	6,111	6,411	6,311	6,611
0	0	0	0	0	0	0	0	0
0	2,700	1,026	0	0	159,959	162,659	101,759	104,459
0	3,000	1,140	0	0	166,070	169,070	108,070	111,070
0	0	0	0	0	0	0	0	0
1,519	1,519	2,416	1,037	958	17,466	17,466	17,466	17,466
0	0	0	0	0	0	0	0	0
2,821	2,821	5,639	1,925	1,778	39,356	39,356	39,356	39,356
4,340	4,340	8,055	2,962	2,736	56,822	56,822	56,822	56,822
6,040	6,040	20,525	2,540	4,050	107,005	107,005	107,005	107,005
10,570	10,570	24,630	3,180	3,240	149,950	149,950	149,950	149,950
7,550	7,550	28,735	4,440	8,100	123,185	123,185	123,185	123,185
6,040	6,040	8,210	2,540	810	78,660	78,660	78,660	78,660
30,200	30,200	82,100	12,700	16,200	458,800	458,800	458,800	458,800
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
5,612	5,612	13,389	3,474	580	86,966	86,966	86,966	86,966
0	0	0	0	0	510	510	510	510
5,612	5,612	13,389	3,474	580	87,476	87,476	87,476	87,476
8,680	8,680	26,275	9,880	4,050	178,017	178,017	178,017	178,017
15,858	17,358	52,370	7,455	14,532	583,092	584,592	583,292	584,792
13,937	13,937	46,274	8,194	8,747	303,527	303,527	303,527	303,527
13,265	17,165	23,325	6,045	5,355	520,814	524,714	394,614	398,514
$51,740	$57,140	$148,244	$31,574	$32,684	$1,585,950	$1,591,350	$1,459,950	$1,465,350

TABLE 2-43. Distribution of project investment costs, Puget Sound Area 2000-2020 ($1000)

Feature	Nooksack-Sumas	Skagit-Samish Alt. A	Skagit-Samish Alt. B	Stillaguamish	Whidbey-Camano Islands	Snohomish	Cedar-Green	Puyallup
M&I Water Supply								
Private	0	0	0	0	0	0	22,087	2,210
Government								
Local	4,998	11,290	11,290	1,152	0	19,465	65,760	57,397
State	0	0	0	0	0	0	0	0
Federal	0	0	0	0	0	0	0	0
Total	4,998	11,290	11,290	1,152	0	19,465	87,847	59,607
Irrigation								
Private	0	2,750	2,750	0	0	175	55	340
Government								
Local	0	0	0	0	0	0	0	0
State	0	0	0	0	0	0	0	0
Federal	0	15,000	15,000	0	0	0	0	0
Total	0	17,750	17,750	0	0	175	55	340
Water Quality Control								
Private	9,000	4,200	4,200	1,380	0	23,200	0	18,400
Government								
Local	13,040	1,850	1,850	840	4,673	8,000	117,000	29,400
State	6,520	925	925	420	2,336	4,000	58,500	14,700
Federal	8,520	1,925	1,925	1,340	3,336	8,500	61,500	17,100
Total	37,080	8,900	8,900	3,980	10,345	43,700	237,000	79,600
Navigation								
Private	0	0	0	0	0	0	0	0
Government								
Local	0	747	747	0	0	0	0	0
State	0	0	0	0	0	0	0	0
Federal	0	2,242	2,242	0	0	0	0	0
Total	0	2,989	2,989	0	0	0	0	0
Flood Control								
Private	0	0	0	0	0	0	0	0
Government								
Local	0	0	0	0	0	3,626	0	0
State	0	0	0	0	0	0	0	0
Federal	0	0	0	0	0	32,629	0	0
Total	0	0	0	0	0	36,255	0	0
Watershed Management								
Private	0	0	0	0	0	0	0	0
Government								
Local	281	467	467	395	0	25	60	0
State	0	0	0	0	0	0	0	0
Federal	655	993	993	915	0	75	140	0
Total	936	1,460	1,460	1,310	0	100	200	0
Recreation								
Private	9,960	14,260	14,260	6,030	13,000	24,640	31,380	22,010
Government								
Local	17,430	21,390	21,390	12,060	13,000	36,960	47,070	30,814
State	12,450	14,260	14,260	14,070	20,710	24,640	20,920	17,608
Federal	9,960	21,390	21,390	8,040	5,190	36,960	5,230	17,608
Total	49,800	71,300	71,300	40,200	51,900	123,200	104,600	88,040
Fish and Wildlife								
Private	0	0	0	0	0	0	0	0
Government								
Local	0	0	0	0	0	0	0	0
State	13,610	23,035	23,035	9,412	734	18,220	16,517	11,517
Federal	0	0	0	0	0	0	0	347
Total	13,610	23,035	23,035	9,412	734	18,220	16,517	11,864
TOTAL								
Private	18,960	21,210	21,210	7,410	13,000	48,015	53,522	42,960
Government								
Local	35,749	35,744	35,744	14,447	17,673	68,076	229,890	117,611
State	32,580	38,220	38,220	23,902	23,780	46,860	95,937	43,825
Federal	19,135	41,550	41,550	10,295	8,526	78,164	66,870	35,055
Total	106,424	136,724	136,724	56,054	62,979	241,115	446,219	239,451
GRAND TOTAL								
Private	65,258	44,413	44,413	16,173	28,050	100,027	103,749	81,087
Government								
Local	84,761	89,465	90,070	32,767	51,609	241,024	565,609	268,212
State	64,254	86,256	86,256	49,688	51,477	101,749	229,055	89,834
Federal	132,668	256,721	137,121	35,755	20,556	330,732	201,522	115,608
Total	$346,941	$475,860	$357,860	$134,383	$151,692	$773,532	$1,099,935	$554,741

[1] Alternative A – Skagit-Samish Basins.

[2] Alternative A – Nisqually-Deschutes Basins.

Nisqually-Deschutes Alt. A	Nisqually-Deschutes Alt. B	West Sound	Elwha-Dungeness	San Juan Islands	Puget Sound Area: Alt. A–S.S.[1] Alt. A–N.D.[2]	Puget Sound Area: Alt. A–S.S. Alt. B–N.D.	Puget Sound Area: Alt. B–S.S. Alt. A–N.D.	Puget Sound Area: Alt. B–S.S. Alt. B–N.D.
0	0	0	0	0	24,297	24,297	24,297	24,297
1,167	1,167	5,360	848	0	167,437	167,437	167,437	167,437
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
1,167	1,167	5,360	848	0	191,734	191,734	191,734	191,734
1,080	1,080	70	0	0	4,470	4,470	4,470	4,470
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	15,000	15,000	15,000	15,000
1,080	1,080	70	0	0	19,470	19,470	19,470	19,470
3,000	3,000	8,000	16,000	0	83,180	83,180	83,180	83,180
2,500	2,500	12,250	1,650	100	191,303	191,303	191,303	191,303
1,250	1,250	6,125	825	50	95,651	95,651	95,651	95,651
3,450	3,450	10,925	2,825	3,450	122,871	122,871	122,871	122,871
10,200	10,200	37,300	21,300	3,600	493,005	493,005	493,005	493,005
0	0	0	0	0	0	0	0	0
0	0	0	0	0	747	747	747	747
0	0	0	0	0	0	0	0	0
0	0	0	0	0	2,242	2,242	2,242	2,242
0	0	0	0	0	2,989	2,989	2,989	2,989
0	0	0	0	0	0	0	0	0
350	350	0	275	0	4,251	4,251	4,251	4,251
0	0	0	0	0	0	0	0	0
3,150	3,150	0	2,475	0	38,254	38,254	38,254	38,254
3,500	3,500	0	2,750	0	42,505	42,505	42,505	42,505
0	0	0	0	0	0	0	0	0
35	35	291	105	0	1,659	1,659	1,659	1,659
0	0	0	0	0	0	0	0	0
65	65	679	195	0	3,717	3,717	3,717	3,717
100	100	970	300	0	5,376	5,376	5,376	5,376
10,730	10,730	33,425	3,960	7,050	176,445	176,445	176,445	176,445
18,820	18,820	40,110	4,955	5,640	248,249	248,249	248,249	248,249
13,420	13,420	46,795	6,925	14,100	205,898	205,898	205,898	205,898
10,730	10,730	13,370	3,960	1,410	133,848	133,848	133,848	133,848
53,700	53,700	133,700	19,800	28,200	764,440	764,440	764,440	764,440
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
7,437	7,437	14,854	1,998	676	118,010	118,010	118,010	118,010
0	0	0	0	0	347	347	347	347
7,437	7,437	14,854	1,998	676	118,357	118,357	118,357	118,357
14,810	14,810	41,495	19,960	7,050	288,392	288,392	288,392	288,392
22,872	22,872	58,011	7,833	5,740	613,646	613,646	613,646	613,646
22,107	22,107	67,774	9,748	14,826	419,559	419,559	419,559	419,559
17,395	17,395	24,974	9,455	4,860	316,279	316,279	316,279	316,279
77,184	77,184	192,254	46,996	32,476	1,637,876	1,637,876	1,637,876	1,637,876
28,965	28,965	87,863	42,132	15,131	685,348	685,348	685,348	685,348
50,441	51,941	139,233	20,418	24,173	1,567,712	1,569,212	1,569,312	1,570,812
47,491	44,991	143,956	24,380	31,864	920,004	917,504	920,004	917,504
37,847	41,747	58,441	33,087	12,295	1,234,237	1,238,137	1,114,637	1,118,537
$164,744	$167,644	$429,493	$120,017	$83,463	$4,407,301	$4,410,201	$4,289,301	$4,292,201

PHOTO 2-26. West Point treatment plant, Seattle. This plant is the largest sewage treatment facility in the Northwest. Municipality of Metropolitan Seattle Photo

ACCOMPLISHMENTS

The accomplishments of the Comprehensive Plan are shown in Tables 2-44, 2-45 and 2-46. All of the quantifiable needs of the Area for municipal and industrial water supply, irrigation, water quality control, and recreation are met under each of the four alternatives. Navigation needs are shown as not being met under Alternative A for the Nisqually-Deschutes Basins as terminal and water transport-oriented development of the Nisqually Delta is precluded. The needs were defined for the Puget Sound Area and satisfaction is predicated upon adequate facilities and back-up land area. Conceivably these needs could be met by more intense development in other basins or use of lands not considered available for development at this time.

Flood control needs are nearly met with over 90 percent of projected damages reduced by elements of the Comprehensive Plan under all four alternatives. Effective implementation of flood plain management with control of land use through zoning is relied upon to provide significant reductions to future growth in flood damages. Without the Sauk River storage project in the Skagit Basin the flood damage reduction accomplishments of the Comprehensive Plan for the 2000-2020 time period would be reduced by $200,000.

Watershed management needs would all be met by the year 2020 with planned programs and projects with some residual shown at the 1980 and 2020 levels due to the lack of sufficient densities of intensive land use in some areas that are needed to facilitate project undertakings.

The sport and commercial fishery needs are assumed to be met by the programs and projects contained in the Plan except under Alternative B for the Nisqually-Deschutes Basins where some fish and wildlife needs would not be met due to navigation development of the Nisqually Delta. The future consumptive withdrawals for municipal and industrial water supply and irrigation would not reduce the minimum flows during the critical summer season over those that have historically occurred. Future municipal and industrial water supply withdrawals are generally planned for accomplishment by drawing water from storage during the summer season with a minimum flow to remain in the stream below the point of diversion. Where a diversion is planned the projects would be carried out in accordance with existing agreements with the Washington Departments of Fisheries and Game. Upon completion of detailed river studies to determine the required minimum and optimum flows for fish production, as called for during the early action period, additional projects may be included in the Plan. These projects could include storage on streams and the possibility of adjusting operations of existing storage projects in order to obtain greater net benefits. During the critical summer seasons the streamflows immediately below the planned storage projects would be at least equal to the inflow. In most cases, higher flows are provided as justified by fishery enhancement benefits.

All of the fisherman-day and commercial fish needs would be satisfied by the Plan assuming that present pollution problems are corrected. However, as only specific solutions for early action were provided for wildlife needs, subsequent periods were assumed to be satisfied by projects and programs that would be developed later or through use of hunting areas outside the Puget Sound Area. A reduction in hunter success is anticipated with a willingness of hunters to accept a lower success ratio necessary in order to meet projected demands.

TABLE 2-44. Comprehensive Plan accomplishments, Puget Sound Area, to 1980

Feature, Units Needs and Accomplishments	Nooksack-Sumas	Skagit-Samish Alt. A	Skagit-Samish Alt. B	Stillaguamish	Whidbey-Camano	Snohomish	Cedar-Green	Puyallup
M&I Water Supply								
MGD								
Needs	83	21.3	21.3	2.3	7.9	102.1	188.3	85.7
Acomplishment	83	21.3	21.3	2.3	7.9	102.1	188.3	85.7
Residual	0	0	0	0	0	0	0	0
Irrigation								
1000 Acre-Feet								
Needs	38	19.1	19.1	7.7	0	12	0	5.9
Accomplishment	38	19.1	19.1	7.7	0	12	0	5.9
Residual	0	0	0	0	0	0	0	0
Water Quality Control								
Waste 1000 P.E.								
Needs	2,981	1,860	1,860	414	85	5,429	1,787	1,063
Accomplishment	2,981	1,860	1,860	414	85	5,429	1,787	1,063
Residual	0	0	0	0	0	0	0	0
Navigation								
Commercial 1000 Short Tons								
Needs	3,200	2,200	2,200	0	0	1,100	9,200	3,700
Accomplishment	3,200	2,200	2,200	0	0	1,100	9,200	3,700
Residual	0	0	0	0	0	0	0	0
Pleasure Boating-Moorages								
Needs	780	1,845	1,845	400	3,668	4,056	5,220	3,000
Accomplishment	870	850	850	0	2,300	3,130	2,100	1,550
Residual	(90)	995	995	400	1,368	926	3,120	1,450
Power – 1000 mw [1]								
Needs								
Accomplishment								
Residual								
Flood Control Acres								
$1000 Damage Reduction								
Needs	1,210	4,340	4,340	380	0	3,520	780	151
Accomplishment	909	4,230	4,250	193	0	2,240	740	123
Residual	301	110	90	187	0	1,280	40	28
Watershed Management								
Flood Prevention 1000 Acres								
Needs	113	120.9	120.9	24.5	24.6	65.6	50.4	48.1
Accomplishments	113	120.9	120.9	24.5	24.6	65.6	50.4	48.1
Residual	0	0	0	0	0	0	0	0
Water Protection & Rehabilitation 1000 Acres								
Needs	792.2	1,912.6	1,912.6	433.6	133	1,194.6	704.2	759.0
Accomplishments	792.2	1,912.6	1,912.6	433.6	133	1,194.6	704.2	759.0
Residual	0	0	0	0	0	0	0	0
Water Management – Agricultural 1000 Acres								
Needs	55.4	49	49	13.5	8.6	25.7	10.6	12.0
Accomplishments	55.4	49	49	13.5	8.6	25.7	10.6	12.0
Residual	0	0	0	0	0	0	0	0
Water Management – Urban 1000 Acres								
Needs	33.6	38.9	38.9	12.6	23.4	65.7	264.9	123.2
Accomplishments	11.4	16.9	16.9	5.6	7.8	43.4	147.5	82.0
Residual	22.2	22.0	22.0	7.0	15.6	22.3	117.4	41.2
Recreation								
1000 User-Days								
Needs	2,600	3,000	3,000	1,240	2,260	5,200	5,700	3,100
Accomplishments	2,600	3,000	3,000	1,240	2,260	5,200	5,700	3,100
Residual	0	0	0	0	0	0	0	0
Fish & Wildlife								
Sport Fishing								
Needs	170	572	572	230	132	625	506	492
Accomplishments	170	572	572	230	132	625	506	492
Residual	0	0	0	0	0	0	0	0
Commercial Fish 1000 lbs.								
Needs	115	360	360	3,133	0	2,551	692	108
Accomplishments	115	360	360	3,133	0	2,551	692	108
Residual	0	0	0	0	0	0	0	0
Hunting – 1000 User-Days								
Needs	69	148	148	51	51	93	50	69
Accomplishments	69	148	148	51	51	93	50	69
Residual	0	0	0	0	0	0	0	0

[1] With the exception of the North Fork Nooksack, Lower Sauk and North Fork Snoqualmie projects only potential developments for electric power production were noted in this study.

Nisqually-Deschutes Alt. A	Nisqually-Deschutes Alt. B	West Sound	Elwha-Dungeness	San Juan	Puget Sound Area Alt. A–S.S.[2] Alt. A–N.D.[3]	Puget Sound Area Alt. A–S.S. Alt. B–N.D.	Puget Sound Area Alt. B–S.S. Alt. A–N.D.	Puget Sound Area Alt. B–S.S. Alt. B–N.D.
8.5	8.5	42.2	75.5	0	618.4	618.4	618.4	618.4
8.5	8.5	42.2	75.5	0	618.4	618.4	618.4	618.4
0	0	0	0	0	0	0	0	0
5.2	5.2	1	29.1	0	118.0	118.0	118.0	118.0
5.2	5.2	1	29.1	0	118.0	118.0	118.0	118.0
0	0	0	0	0	0	0	0	0
166	166	542	2,681	17	17,025	17,025	17,025	17,025
166	166	542	2,681	17	17,025	17,025	17,025	17,025
0	0	0	0	0	0	0	0	0
200	200	0	500	0	27,500 [4]	27,500 [4]	27,500 [4]	27,500 [4]
200	200	0	500	0	27,500	27,500	27,500	27,500
0	0	0	0	0	0	0	0	0
650	650	8,600	1,120	2,410	31,749	11,749	31,749	31,749
230	230	4,310	710	1,480	17,540	17,540	17,540	17,540
420	420	4,290	410	930	14,209	14,209	14,209	14,209
69	69	68	38	0	10,556	10,556	10,556	10,556
40	40	16	5	0	496	496	8,516	8,516
29	29	52	33	0	060	060	2,040	2,040
30.3	30.3	44.5	15.9	17.3	555.1	555.1	555.1	555.1
30.3	30.3	44.5	15.9	17.3	555.1	555.1	555.1	555.1
0	0	0	0	0	0	0	0	0
635.6	635.6	1,281.4	446.6	111.6	8,404.4	8,404.4	8,404.4	8,404.4
635.6	635.6	1,281.4	446.6	111.6	8,404.4	8,404.4	8,404.4	8,404.4
0	0	0	0	0	0	0	0	0
5.3	5.3	17.1	9.6	9.9	216.7	216.7	216.7	216.7
5.3	5.3	17.1	9.6	9.9	216.7	216.7	216.7	216.7
0	0	0	0	0	0	0	0	0
39.8	39.8	106.4	11.0	11.9	731.4	731.4	731.4	731.4
39.8	39.8	35.5	3.7	4.0	397.6	397.6	397.6	397.6
0	0	70.9	7.3	7.9	333.8	333.8	333.8	333.8
2,590	2,590	5,100	900	1,400	33,090	33,090	33,090	33,090
2,590	2,590	5,100	900	1,400	33,090	33,090	33,090	33,090
0	0	0	0	0	0	0	0	0
401	401	424	145	66	3,763	3,763	3,763	3,763
401	401	424	145	66	3,763	3,763	3,763	3,763
0	0	0	0	0	0	0	0	0
123	123	278	922	0	8,282	8,282	8,282	8,282
123	123	278	922	0	8,282	8,282	8,282	8,282
0	0	0	0	0	0	0	0	0
67	67	120	24	46	788	788	788	788
67	40	120	24	46	788	788	788	788
0	27	0	0	0	0	0	0	0

[2] Alternative A – Skagit Samish Basins.

[3] Alternative A – Nisqually Deschutes Basins.

[4] Includes minor port not shown in individual basins.

TABLE 2-45. Comprehensive Plan accomplishments, Puget Sound Area, to 2000

Feature, Units Needs and Accomplishments 2000	Nooksack- Sumas	Skagit- Samish Alt. A	 Alt. B	Stilla- guamish	Whidbey- Camano	Snohomish	Cedar- Green	Puyallup
M&I Water Supply								
MGD								
Needs	139	49.1	49.1	6.7	15.6	255.3	418.5	228.3
Accomplishment	139	49.1	49.1	6.7	15.6	255.3	418.5	228.3
Residual	0	0	0	0	0	0	0	0
Irrigation								
1000 Acre-Feet								
Needs	76	38.3	38.3	15.4	0	19	1	17.7
Accomplishment	76	38.3	38.3	15.4	0	19	1	17.7
Residual	0	0	0	0	0	0	0	0
Water Quality Control								
Waste–1000 P.E.								
Needs	3,503	2,331	2,331	941	136	5,722	3,414	2,013
Accomplishment	3,503	2,331	2,331	941	136	5,722	3,414	2,013
Residual	0	0	0	0	0	0	0	0
Navigation								
Commercial–1000 Short Tons								
Needs	11,500	6,200	6,200	0	0	8,200	19,800	14,000
Accomplishment	11,500	6,200	6,200	0	0	8,200	19,800	14,000
Residual	0	0	0	0	0	0	0	0
Pleasure Boating–Moorages								
Needs	1,410	3,375	3,375	770	6,198	8,666	15,500	7,100
Accomplishments	1,420	3,745	3,745	0	6,328	8,796	15,240	5,720
Residual	(10)	(370)	(370)	770	(130)	(130)	260	1,380
Power–1000 mw [1]								
Needs								
Accomplishment								
Residual								
Flood Control–Acres								
$1000 Damage Reduction								
Needs	1,970	7,060	7,060	690	0	6,370	1,700	301
Accomplishment	1,710	6,813	6,753	496	0	5,180	1,680	275
Residual	260	247	307	194	0	1,190	20	26
Watershed Management								
Flood Prevention 1000 Acres								
Needs	113	120.9	120.9	24.5	24.6	65.6	50.4	48.1
Accomplishment	113	120.9	120.9	24.5	24.6	65.6	50.4	48.1
Residual	0	0	0	0	0	0	0	0
Water Protection & Rehabilitation 1000 Acres								
Needs	792.2	1,912.6	1,912.6	433.6	133	1,194.6	704.2	759.0
Accomplishment	792.2	1,912.6	1,912.6	433.6	133	1,194.6	704.2	759.0
Residual	0	0	0	0	0	0	0	0
Water Management–Agricultural 1000 Acres								
Needs	92.3	81.7	81.7	22.6	14.4	42.9	17.8	19.9
Accomplishment	92.3	81.7	81.7	22.6	14.4	42.9	17.8	19.9
Residual	0	0	0	0	0	0	0	0
Water Management–Urban 1000 Acres								
Needs	33.6	38.9	38.9	12.6	23.4	81.0	317.2	123.6
Accomplishment	22.0	27.5	27.5	9.1	15.3	81.0	290.7	123.6
Residual	11.6	11.4	11.4	3.5	8.1	0	26.5	0
Recreation								
1000 User-Days								
Needs	6,300	7,000	7,000	2,640	4,300	12,000	14,400	7,800
Accomplishment	6,300	7,000	7,000	2,640	4,300	12,000	14,400	7,800
Residual	0	0	0	0	0	0	0	0
Fish & Wildlife								
Sport-Fishing 1000 User-Days								
Needs	425	1,431	1,431	562	375	1,534	1,266	1,250
Accomplishment	425	1,431	1,431	562	375	1,534	1,266	1,250
Residual	0	0	0	0	0	0	0	0
Commerical Fish 1000 lbs.								
Needs	2,610	3,692	3,692	5,290	0	3,387	2,186	1,928
Accomplishment	2,610	3,692	3,692	5,290	0	3,387	2,186	1,928
Residual	0	0	0	0	0	0	0	0
Hunting								
Needs	159	339	339	116	116	212	116	159
Accomplishment	159	339	339	116	116	212	116	159
Residual	0	0	0	0	0	0	0	0

[1] With exception of the North Fork Nooksack, Lower Sauk and North Fork Snoqualmie projects only potential developments for electric power production were noted in this study.

Nisqually-Deschutes Alt. A	Nisqually-Deschutes Alt. B	West Sound	Elwha-Dungeness	San Juan	Puget Sound Area: Alt. A–S.S.[2] Alt. A–N.D.[3]	Puget Sound Area: Alt. A-S.S. Alt. B-N.D.	Puget Sound Area: Alt. B-S.S. Alt. A-N.D.	Puget Sound Area: Alt. B-S.S. Alt. B-N.D.
16.9	16.9	89.9	144.8	0.2	1,364.3	1,364.3	1,364.3	1,364.3
16.9	16.9	89.9	144.8	0.2	1,364.3	1,364.3	1,364.3	1,364.3
0	0	0	0	0	0	0	0	0
17.1	17.1	2.3	29.1	0	215.9	215.9	215.9	215.9
17.1	17.1	2.3	29.1	0	215.9	215.9	215.9	215.9
0	0	0	0	0	0	0	0	0
315	315	929	2,856	24	22,184	22,184	22,184	22,184
315	315	929	2,856	24	22,184	22,184	22,184	22,184
0	0	0	0	0	0	0	0	0
5,200	5,200	0	1,500	0	83,400[4]	83,400[4]	83,400[4]	83,400[4]
1,200	5,200	0	1,500	0	79,400	83,400	79,400	83,400
4,000	0	0	0	0	4,000	0	4,000	0
1,430	1,430	17,280	1,900	4,210	67,839	67,839	67,839	67,839
2,830	2,830	17,310	1,920	4,210	66,869	66,869	66,869	66,869
(1,400)	(1,400)	(30)	(20)	0	970	970	970	970
110	110	100	54	0	18,355	18,355	18,355	18,355
77	77	74	17	0	16,342	16,342	16,262	16,262
33	33	26	37	0	2,033	2,033	2,093	2,093
30.3	30.3	44.5	15.9	17.3	555.1	555.1	555.1	555.1
30.3	30.3	44.5	15.9	17.3	555.1	555.1	555.1	555.1
0	0	0	0	0	0	0	0	0
635.6	635.6	1,281.4	446.6	111.6	8,404.4	8,404.4	8,404.4	8,404.4
635.6	635.6	1,281.4	446.6	111.6	8,404.4	8,404.4	8,404.4	8,404.4
0	0	0	0	0	0	0	0	0
9.0	9.0	28.6	16.1	16.4	361.7	361.7	361.7	361.7
9.0	9.0	28.6	16.1	16.4	361.7	361.7	361.7	361.7
0	0	0	0	0	0	0	0	0
39.8	39.8	106.4	11.0	11.9	799.4	799.4	799.4	799.4
39.8	39.8	72.6	7.3	7.8	696.7	696.7	696.7	696.7
0	0	33.8	3.7	4.1	102.7	102.7	102.7	102.7
5,900	5,900	12,700	1,850	3,000	77,890	77,890	77,890	77,890
5,900	5,900	12,700	1,850	3,000	77,890	77,890	77,890	77,890
0	0	0	0	0	0	0	0	0
1,016	1,016	1,064	394	194	9,511	9,511	9,511	9,511
1,016	1,016	1,064	394	194	9,511	9,511	9,511	9,511
0	0	0	0	0	0	0	0	0
2,191	2,191	5,169	1,441	0	27,894	27,894	27,894	27,894
2,191	2,191	5,169	1,441	0	27,894	27,894	27,894	27,894
0	0	0	0	0	0	0	0	0
154	154	274	55	105	1,805	1,805	1,805	1,805
154	127	274	55	105	1,805	1,778	1,805	1,778
0	27	0	0	0	0	27	0	27

[2] Alternative A—Skagit-Samish Basins.

[3] Alternative A—Nisqually-Deschutes Basins.

[4] Includes minor ports not shown in individual basins.

TABLE 2-46. Comprehensive Plan accomplishments, Puget Sound Area, to 2020

Feature, Units / Needs and Accomplishments	Nooksack-Sumas	Skagit-Samish Alt. A	Skagit-Samish Alt. B	Stillaguamish	Whidbey-Camano	Snohomish	Cedar-Green	Puyallup
M&I Water Supply								
MGD								
Needs	220	88.5	88.5	14.4	25.5	375.9	957.1	446.9
Accomplishment	220	88.5	88.5	14.4	25.5	375.9	957.1	446.9
Residual	0	0	0	0	0	0	0	0
Irrigation								
1000 Acre Feet								
Needs	76	86.3	86.3	15.4	0	22	2	23.7
Accomplishments	76	86.3	86.3	15.4	0	22	2	23.7
Residual	0	0	0	0	0	0	0	0
Water Quality Control								
Waste 1000 P.E.								
Needs	3,966	2,042	2,042	1,821	181	5,700	6,086	3,019
Accomplishments	3,966	2,042	2,042	1,821	181	5,700	6,086	3,019
Residual	0	0	0	0	0	0	0	0
Navigation								
Commercial–1000 Short Tons								
Needs	27,900	23,600	23,600	0	0	47,300	37,200	17,200
Accomplishments	27,900	23,600	23,600	0	0	47,300	37,200	17,200
Residual	0	0	0	0	0	0	0	0
Pleasure Boating–moorages								
Needs	2,490	5,985	5,985	1,500	10,588	17,656	35,500	15,050
Accomplishment	2,570	7,085	7,085	0	10,588	23,675	15,240	5,720
Residual	(80)	(1,100)	(1,100)	1,500	0	(6,019)	20,260	9,330
Power [1]								
1000 mgw								
Needs								
Accomplishment								
Residual								
Flood Control Acres								
$1000 Damage Reduction								
Needs	3,350	12,030	12,030	1,310	0	13,100	3,740	602
Accomplishment	2,945	11,793	11,593	1,116	0	11,679	3,700	339
Residual	405	237	437	194	0	1,421	40	263
Watershed Management								
Flood Prevention 1000 Acres								
Needs	113	120.9	120.9	24.5	24.6	65.6	50.4	48.1
Accomplishments	113	120.9	120.9	24.5	24.6	65.6	50.4	48.1
Residual	0	0	0	0	0	0	0	0
Water Protection & Rehabilitation 1000 Acres								
Needs	792.2	1,912.6	1,912.6	433.6	133	1,194.6	704.2	759.0
Accomplishments	792.2	1,912.6	1,912.6	433.6	133	1,194.6	704.2	759.0
Residual	0	0	0	0	0	0	0	0
Water Management–Agricultural 1000 Acres								
Needs	123.1	108.9	108.9	30.1	19.2	57.2	23.7	26.6
Accomplishments	123.1	108.9	108.9	30.1	19.2	57.2	23.7	26.6
Residual	0	0	0	0	0	0	0	0
Water Management–Urban 1000 Acres								
Needs	33.6	38.9	38.9	13	23.4	130.1	433.7	198.5
Accomplishments	33.6	38.9	38.9	13	23.4	130.1	433.7	198.5
Residual	0	0	0	0	0	0	0	0
Recreation								
1000 user-days								
Needs	12,900	13,900	13,900	5,140	9,300	24,000	29,900	16,100
Accomplishment	12,900	13,900	13,900	5,140	9,300	24,000	29,900	16,100
Residual	0	0	0	0	0	0	0	0
Fish and Wildlife								
Sport fishing 100 user-days								
Needs	835	2,828	2,828	1,107	748	3,024	2,516	2,476
Accomplishment	835	2,828	2,828	1,107	748	3,024	2,516	2,476
Residual	0	0	0	0	0	0	0	0
Commercial fish 1000 lbs.								
Needs	4,278	7,940	7,940	7,366	0	6,202	4,922	4,278
Accomplishment	4,278	7,940	7,940	7,366	0	6,202	4,922	4,278
Residual	0	0	0	0	0	0	0	0
Hunting								
Needs	213	455	455	155	156	284	156	213
Accomplishment	213	455	455	155	156	284	156	213
Residual	0	0	0	0	0	0	0	0

[1] With exception of the North Fork Nooksack, Lower Sauk and North Fork Snoqualmie projects only potential developments for electric power production were noted in this study.

Nisqually-Deschutes Alt. A	Nisqually-Deschutes Alt. B	West Sound	Elwha-Dungeness	San Juan	Puget Sound Area Alt. A–S.S.[2] Alt. A–N.D.[3]	Puget Sound Area Alt. A-S.S. Alt. B-N.D.	Puget Sound Area Alt. B-S.S. Alt. A-N.D.	Puget Sound Area Alt. B-S.S. Alt. B-N.D.
33.5	33.5	132.2	207	0.6	2,502.6	2,502.6	2,502.6	2,502.6
33.5	33.5	132.2	207	0.6	2,502.6	2,502.6	2,502.6	2,502.6
0	0	0	0	0	0	0	0	0
36	36	3.5	29.1	0	294.0	294.0	294.0	294.0
36	36	3.5	29.1	0	294.0	294.0	294.0	294.0
0	0	0	0	0	0	0	0	0
561	561	1,306	2,812	43	27,537	27,537	27,537	27,537
561	561	1,306	2,812	43	27,537	27,537	27,537	27,537
0	0	0	0	0	0	0	0	0
23,500	23,500	0	3,000	0	214,000[4]	214,000[4]	214,000[4]	214,000[4]
4,000	23,500	0	3,000	0	194,500	214,000	194,500	214,000
19,500	0	0	0	0	19,500	0	19,500	0
2,180	2,180	30,580	2,620	7,260	131,409	131,409	131,409	131,409
4,040	4,040	30,530	2,620	7,260	109,328	109,328	109,328	109,328
(1,860)	(1,860)	50	0	0	22,081	22,081	22,081	22,081
160	160	158	80	0	34,530	34,530	34,530	34,530
153	153	120	43	0	31,888	31,888	31,688	31,688
7	7	38	37	0	2,642	2,642	2,842	2,842
30.3	30.3	44.5	15.9	17.3	555.1	555.1	555.1	555.1
30.3	30.3	44.5	15.9	17.3	555.1	555.1	555.1	555.1
0	0	0	0	0	0	0	0	0
635.6	635.6	1,281.4	446.6	111.6	8,404.4	8,404.4	8,404.4	8,404.4
635.6	635.6	1,281.4	446.6	111.6	8,404.4	8,404.4	8,404.4	8,404.4
0	0	0	0	0	0	0	0	0
11.9	11.9	38.1	21.4	21.9	482.1	482.1	482.1	482.1
11.9	11.9	38.1	21.4	21.9	482.1	482.1	482.1	482.1
0	0	0	0	0	0	0	0	0
39.8	39.8	106.4	11	11.9	1,040.3	1,040.3	1,040.3	1,040.3
39.8	39.8	106.4	11	11.9	1,040.3	1,040.3	1,040.3	1,040.3
0	0	0	0	0	0	0	0	0
12,800	12,800	26,200	3,950	6,000	160,190	160,190	160,190	160,190
12,800	12,800	26,200	3,950	6,000	160,190	160,190	160,190	160,190
0	0	0	0	0	0	0	0	0
2,009	2,009	2,097	887	389	18,916	18,916	18,916	18,916
2,009	2,009	2,097	887	389	18,916	18,916	18,916	18,916
0	0	0	0	0	0	0	0	0
4,197	4,197	8,869	1,643	0	49,695	49,695	49,695	49,695
4,197	4,197	8,869	1,643	0	49,695	49,695	49,695	49,695
0	0	0	0	0	0	0	0	0
206	206	368	73	141	2,420	2,420	2,420	2,420
206	179	368	73	141	2,420	2,393	2,420	2,393
0	27	0	0	0	0	27	0	27

[2] Alternative A–Skagit-Samish Basins.

[3] Alternative A–Nisqually-Deschutes Basins.

[4] Includes minor ports not shown in individual basins.

EFFECTS OF THE PLAN

GENERAL

The Puget Sound Area has a heritage of a high quality environment with coordinated planning for the future being necessary to retain and improve this environment. The basic objective in the formulation of plans was to provide the best use, or combination of uses, of water and related land resources to meet all foreseeable short and long-term needs. In pursuit of this basic conservation objective, full consideration was given to preservation, development opportunities and the well-being of the people. The overriding determinant was the well-being of the people. The following chapter evaluates the effects of plan implementation on the Puget Sound Area.

PRESERVATION OF WATER AND RELATED LAND

The land-use planning, undertaken on a broad basis, sought to retain as much of the lands currently in forest and cropland as possible to meet the food and fiber needs. In order to accomplish this objective the future population projected for the Area would be required to occupy land at a greater density than is now the case. The planning for the Puget Sound Area population expected by the year 2020 employed a density of 9.9 persons per acre compared with the existing average urban density of 4.35 persons per acre. This was done in order to preserve as much land as possible in the forest and cropland categories, necessary to meet the food and fiber needs of the Puget Sound Area and the Nation. The Plan also provides for watershed management measures that would increase the efficiency of current land use and rectify some of the abuses that have occurred in the past through improper management or neglect. The future use of surface waters which include the streams and lakes is planned to enable continued fish production in all the streams, and to allow for increased production through the implementation of the enhancement measures. In all basins the Comprehensive Plan provides for minimum streamflow to be retained for both fish use and water quality control. Detail stream surveys planned for implementation prior to 1980 would provide a basis for refined planning and determination of optimum flow requirements in major streams of the Area. Conflicting demands are being made on the marine waters and coastal shoreline to satisfy economic development needs and to meet requirements for preservation of the natural environment. The Comprehensive Plan attempts to accommodate as much of the future demands for this resource as possible by providing for balanced use of the marine shoreline as well as abating water pollution that hampers and limits production of shellfish and other species that inhabit these areas.

PRESERVATION OF FREE-FLOWING RIVERS

A large number of streams have been designated for possible inclusion in a State system of recreational rivers. These streams, listed below, are recommended for further study for preservation in a natural free-flowing state of their entirety or portions thereof, with stream access retained for public use.

<u>Noosack-Sumas Basins</u>
Mainstem, North, Middle, and South Forks of Nooksack River

<u>Skagit-Samish Basins</u>
Cascade, Suiattle, and portions of the Sauk and Skagit

<u>Stillaguamish Basin</u>
North and South Forks of Stillaguamish River

<u>Snohomish Basin</u>
South Fork of Snoqualmie, and portions of the North and Middle Forks of Snoqualmie, Skykomish, Wallace, Beckler, Miller, Foss, Tyee and Pilchuck Rivers

<u>Cedar-Green Basins</u>
Sammamish River, portions of Cedar and Green

<u>Puyallup Basin</u>
Carbon, and portions of White and Puyallup Rivers

<u>Nisqually-Deschutes Basins</u>
Nisqually River

West Sound Basins
North and South Forks Skokomish, Hamma Hamma, Duckabush, Dosewallips and Big Quilcene Rivers

Elwha-Dungeness Basins
Elwha and Dungeness Rivers and Morse Creek

A 165-mile portion of the Skagit River and several tributaries have been designated in an alternative plan for the Skagit-Samish Basins for inclusion in the National Wild and Scenic Rivers system. This complex is currently under study by the Departments of Agriculture and Interior for recommendations to Congress.

PRESERVATION OF ESTUARIES AND COASTAL ZONES

The management of the sea coast, estuaries and related shorelands of Puget Sound Area is concerned with the use and care of natural resource values and productivity. These waters and related land constitute one of the Puget Sound Area's most valuable geographic features. The pressures for shoreline space and water surface use have increased rapidly in recent years and are expected to accelerate. The Comprehensive Plan includes the following provisions for management and control and preservation of estuaries and coastal zones:

Institution of water quality measures, including waste treatment by municipalities and industry; construction of marine outfalls and diffusers to properly disperse treated wastes; and expansion of water quality surveillance programs to insure compliance with State water quality standards which protect the estuaries.

Retention of all shorelands now in public ownership with emphasis on additional acquisition and development of salt water beaches and pedestrian crossings along the railroad right-of-way which follows the shoreline of Puget Sound from Seattle to Everett.

Preservation of the estuaries and protection of marine waters to provide continued opportunities for fishing and hunting; and acquisition of marine shorelines for habitat as well as access.

Identification of specific erosion sites and determination of correction measures, as erosion of the shoreline not only destroys developments and adjacent properties but contributes to deposition of silt in the estuaries.

Finally, development of a coordinated State program for future sea coast resource use.

PRESERVATION OF UNIQUE AND HISTORICAL AREAS

Numerous archeological, historical, outstanding natural and underwater marine areas have been identified in the study. The Plan provides for more significant and interesting features to be classified, protected and properly developed for public enjoyment and scientific purposes. These areas are identified in Appendix X, Recreation.

WELFARE OF PEOPLE

The welfare of the people was the overriding consideration in the study which sought to provide opportunities for improved living environment. The basic needs of particular groups such as those having a special interest in resource development for either economic or environmental purposes were considered. The overall welfare of the general public was viewed as being paramount and care was taken to avoid resource use and development for the benefit of a few or the disadvantage of many. The depletion of a resource for a single purpose was not considered to be in the interest of the public. The Comprehensive Plan was designed to provide for balanced use of Puget Sound Area resources. Minimum streamflows for fish, water quality and aesthetic purposes were retained in all of the major streams in the Area with provision made for reconsideration of plan elements after the stream surveys planned for early action are completed.

The socio-economic environment of the Puget Sound Area has been considered to be one of the best in the Nation and has accounted for substantial immigration to the Area. The population has grown from 1.7 million to 2.1 million within the past ten years. The people of the Area have combined their skills with the natural resources to develop an industrial complex heavily oriented toward aerospace, forest products, ship building, trade, transportation and diversified manufacturing. In addition, commer-

cial fisheries and recreation activities, agriculture, timber production and sport fishing and related recreation activities have long been important to the Puget Sound Area economy. The contrasts and variations that occur in the economic conditions in various parts of the Puget Sound Area are a result of the urbanization of the eastern shoreline with natural resources and transportation influencing the pattern of economic development in other parts of the Area. The Area is primarily split into three economic areas with the Central Division containing the industrial complex and 80 percent of the Area's population. The North Division accounts for 30 percent of the Area's commercial forest land with the agriculture, timber production and fishing and related activities the main factors of the economy. In the West Division the waters of the Strait of Juan de Fuca support in abundance marine-oriented recreation and fish and wildlife activities. In this area trade and service industries have been expanding to meet the present and anticipated needs for recreation.

The living environment would be improved by the provisions in the Comprehensive Plan for adequate water supply, recreation facilities, restoration and maintenance of the quality of streams and estuaries, provision of access to water areas for public use and enjoyment, the provisions for preservation of selected natural stream reaches in a free-flowing state, and retention of sites of historical significance and areas of unique natural beauty. The reduction of flooding would help to alleviate health problems associated with flood flows and provide for improvement of the welfare of those residing in the flood plain. The flood protection provided by plan elements would, together with land use zoning, allow for continued economic farming of croplands in the flood plain thereby satisfying the needs for food and fiber as well as providing open space and greenbelts for the enjoyment of sightseeing urban dwellers. Irrigation also would help maintain a stable economy and at the same time provide open space and green areas. The recreation facilities planned for the Area, in urban and rural areas, including the small boat harbors, and the fish and wildlife enhancement projects are designed to enhance the social environment.

The outdoor recreation facilities would enable various groups such as the Boy Scouts, Girl Scouts, Y.M.C.A., and other similar social organizations to have additional opportunities for their activities. The urban dweller who is generally quite mobile would be provided with many opportunities to meet his outdoor recreation needs. The production of food and fiber would be enhanced by projects designed to increase yields through drainage improvement and better land use management. The planning undertaken in this study attempts to direct urban growth in such a manner that it would be related to and integrated with the natural environment, providing for an ecological improvement.

Regional systems of water supply and sewerage collection and treatment are planned to provide a more efficient use of the resources thereby allowing more of the natural resources to be left for recreation and aesthetic enjoyment.

The study sought to provide a good inventory of soil characteristics which can be used for detailed land use planning and zoning to encourage urban development on those lands that are suitable for this purpose. The Comprehensive Plan in its entirety supports the retention of flood plains for agricultural production in those areas that are considered to be uniquely suited for this purpose. Large expanses of open space land are planned for retention near urban areas. Developing public access along the marine shoreline, within the urban areas, is viewed as a high priority element. Rural considerations involve the drainage and flood damage reduction projects and would provide an improved environment for those choosing to live in rural areas.

The Comprehensive Plan is designed to accommodate the projected economy for the Puget Sound Area through the year 2020. The economic projections were translated into needs for food and fiber, water supply and power. The Plan provides that these necessary inputs to the economic well-being of the Area would be available in accordance with the projections. Comprehensive Plan elements would play an important role in enabling economic growth of the Puget Sound Area to continue. The provisions for improved navigation channels would facilitate water-borne commerce which is a growing factor in the local economy. Puget Sound is a unique harbor with deep waters capable of accommodating the largest of present and planned ocean-going vessels. The retention of sufficient back-up lands for terminal and water transport-oriented industry also is an important measure which would contribute to the economy of the Puget Sound Area.

Water supply has been planned to satisfy industrial needs with industry expected to account for 60 percent of the total water consumed within the Puget Sound Area by the year 2020. Adequate quantity and quality of water are necessary for

continued industrial development in the Area. Irrigation and watershed management measures would enable increased production of food and fiber supporting those industries related to agriculture and forestry and wood products.

The assessment of future acreage requirements for cropland, forests, and rangeland provides important information for use in guiding future intensive land use development to enable sufficient acreages of the foregoing categories to be relegated to satisfying Area and national needs for food and fiber.

RELATIONSHIP TO NATIONAL ENVIRONMENTAL POLICY ACT OF 1969

The Comprehensive Plan has as one of its primary objectives that of environmental preservation and enhancement as demonstrated above. Although the National Policy Act of 1969 was not in force during the course of the study its purposes were adhered to by conformance with existing State and Federal laws, regulations and policies.

In response to increasing citizen concern Public Law 91-190 known as the National Environmental Policy Act of 1969 was signed into law on January 1, 1970. The stated purposes of the Act are:

> "To declare a national policy which will encourage production and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation; and to establish a Council on Environmental Quality."

Section 101 of the Act declares the policies and goals to be:

> "The Congress, recognizing the profound impact of man's activity on the interrelations of all components of the natural environment, particularly the profound influences of population growth, high-density urbanization, industrial expansion, resource exploitation, and new and expanding importance of restoring and maintaining environmental quality to the overall welfare and development of man, declares that it is the continuing policy of the Federal Government, in cooperation with State and local governments, and other concerned public and private organizations, to use all practicable means and measures, including financial and technical assistance, in a manner calculated to foster and promote the general welfare, to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans.
>
> (b) In order to carry out the policy set forth in this Act, it is the continuing responsibility of the Federal Government to use all practicable means, consistent with other essential considerations of national policy, to improve and coordinate Federal plans, functions, programs, and resources to the end that the Nation may–
>
> (1) fulfill the responsibilities of each generation as trustee of the environment for succeeding generations;
>
> (2) assure for all Americans safe, healthful, productive, and esthetically and culturally pleasing surroundings;
>
> (3) attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences;
>
> (4) preserve important historic, cultural, and natural aspects of our national heritage, and maintain, wherever possible, an environment which supports diversity and variety of individual choice;
>
> (5) achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities; and
>
> (6) enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.
>
> (c) The Congress recognizes that each person should enjoy a healthful environment and that each person has a responsibility to contribute to the preservation and enhancement of the environment."

Prior to implementation of any portion of the Puget Sound and Adjacent Waters Comprehensive Plan and as part of detailed project authorization studies all Federal agencies must conform with Section 102 of the Act which states:

"The Congress authorizes and directs that, to the fullest extent possible: (1) the policies, regulations, and public laws of the United States shall be interpreted and administered in accordance with the policies set forth in this Act, and (2) all agencies of the Federal Government shall—

(A) utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decisionmaking which may have an impact on man's environment;

(B) identify and develop methods and procedures, in consultation with the Council on Environmental Quality established by title II of this Act, which will insure that presently unquantified environmental amenities and values may be given appropriate consideration in decisionmaking along with economic and technical considerations;

(C) include in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a detailed statement by the responsible official on—

(i) the environmental impact of the proposed action,

(ii) any adverse environmental effects which cannot be avoided should the proposal be implemented,

(iii) alternatives to the proposed action,

(iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and

(v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

Prior to making any detailed statement, the responsible Federal official shall consult with and obtain the comments of any Federal agency which has jurisdiction by law or special expertise with respect to any environmental impact involved. Copies of such statement and the comments and views of the appropriate Federal, State, and local agencies, which are authorized to develop and enforce environmental standards, shall be made available to the President, the Council on Environmental Quality and to the public as provided by section 552 of title 5, United States Code, and shall accompany the proposal through the existing agency review processes;

(D) study, develop, and describe appropriate alternatives to recommend courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources;

(E) recognize the worldwide and long-range character of environmental problems and, where consistent with the foreign policy of the United States, lend appropriate support to initiatives, resolutions, and programs designed to maximize international cooperation in anticipating and preventing a decline in the quality of mankind's world environment;

(F) make available to States, counties, municipalities, institutions, and individuals, advice and information useful in restoring, maintaining, and enhancing the quality of the environment;

(G) initiate and utilize ecological information in the planning and development of resource-oriented projects; and

(H) assist the Council on Environmental Quality established by title II of this Act."

The planning undertaken in this study was in full agreement with the sense of the National Environmental Policy Act with a balance sought in satisfying economic needs, resource preservation and restoration and enhancement of the natural environment. Recommendations or reports on individual proposals for Federal legislation, for which this study acts as a guide, will be accompanied by detailed statements required by Section 102 of the Act. Adherence to the principles of the Act also should be sought in implementing non-Federal elements of the Comprehensive Plan.

ADDITIONAL STUDY REQUIREMENTS

Problem areas unresolved by this study include the future use of the Skagit River and the Nisqually Delta. The Skagit River is under consideration for possible designation as a National Scenic, Wild or Recreation River. Additional flood control and hydroelectric power development are possible in the Skagit River Basin from a multiple-purpose storage project on the Sauk River.

In the Nisqually River delta, opportunities exist for development of a wildlife refuge and recreation area as well as for terminal and water transport-oriented industrial development. The latter is favorable because of deep water navigation access, land area and rail and highway transportation considerations. Further studies and public expression are required before a final determination can be made as to the best use or uses of these areas.

An equitable method of sharing of water treatment facilities investment and increased operating costs is required before municipal watersheds should be opened to satisfy outdoor recreation needs. The treatment facilities are needed to insure protection of public health. Public expression on this issue also is considered to be desirable and perhaps necessary.

Additional detailed land use planning, with due regard given to urban needs, is suggested as an adjunct to this study. A comprehensive detailed land use plan is needed to insure that future industrial and residential needs of the Area would be met in a manner that is harmonious with the environment.

PLAN IMPLEMENTATION

The Comprehensive Plan provides a framework for guiding the orderly development of the water and related land resources to meet the foreseeable needs of the Area. The Plan has been formulated on the basis of providing the best uses and combination of uses of the resources in meeting economic and environmental objectives. Implementation of the Plan would require the acceptance and support of the public. Because of the varied and wide range of interests, coordination between local, State and Federal groups and agencies is of extreme importance. Further detailed studies also are necessary before some specific elements can be implemented and periodic updating of the Plan itself must be undertaken in order to remain relevant. Expenditures at all levels of government, and by the private sector, are necessary for Plan implementation. However, many expenditures called for by the Plan are already included in on-going programs. An entity representing various levels of government is required to coordinate future development within the framework of the Comprehensive Plan and to provide a means of updating the Plan. The existing Puget Sound and Adjacent Waters Task Force or some similar entity could be the logical body to provide future leadership and guidance in performing this task. Authorities and responsibilities of various local, State and Federal bodies are outlined in Appendix II, Political and Legislative Environment. Plan implementation is discussed in detail in the Summary Report.

COMPREHENSIVE PLAN IMPACTS FROM OBERS PROJECTIONS

COMPARISON OF PROJECTIONS

The population and economic projections used in the Puget Sound and Adjacent Waters Comprehensive Water and Related Land Resource (PS&AW) "Type 2" Study were completed in late 1967 and differ in some degree with 1968 projections made by the Regional Economics Division, Office of Business Economics, and the Economic Research Service (OBE-ERS). The OBERS projections are contained in a report entitled, "Preliminary Report on Economic Projections for Selected Geographic Areas, 1929 to 2020, Volume I," published by the United States Water Resources Council, Washington, D.C., March 1968 and were prepared for use in the Columbia-North Pacific Region Comprehensive Framework Study as well as other similar regional "Type I" studies.

Both economic studies recognize that Area growth will be dependent upon future national regional economic opportunities and that the level of future Area population will respond to these opportunities. The methodology in both studies analyzes and projects Area employment opportunities and the Area population. However, the presentation of the projected economic indicators differ:

> The OBERS study provides projections for the Puget Sound Economic Area in terms of population, income, earnings and employment in nine categories; employment participation rate, and economic production per employee for six large water using industries. Dollar values are in terms of 1958 dollars.
>
> The PS&AW Study presents projections in terms of population, age-sex composition, employment, output and value added for 56 industries. Dollar values are in terms of 1963 dollars.

Projections in the two studies are most readily comparable in terms of population and employment. Tables 2-47 and 2-48 show the direction and magnitude of the major economic parameters of population and employment:

TABLE 2-47. Total employment—Puget Sound Economic Area (comparison of OBERS and PS&AW projections) 1980-2000-2020

Year	OBERS	PS&AW	Difference PS&AW Over OBERS Number	Percent
1980	978,681	973,100	-5,581	-0.6
2000	1,338,231	1,535,400	197,169	15
2020	1,773,299	2,434,400	661,101	37

TABLE 2-48. Population—Puget Sound Economic Area (comparison of OBERS and PS&AW projections) 1980-2000-2020

			Difference PS&AW Over OBERS		
Year	OBERS	PS&AW	Number	Percent of OBERS	Percent of PS&AW
1980	2,449,700	2,726,900	277,200	11	10
2000	3,345,300	4,300,500	955,200	29	22
2020	4,448,100	6,809,400	2,361,300	53	35

The above Tables 2-47 and 2-48 show that the projections are fairly similar for the period up to 1980. However, as they extend forward in time to the year 2000 and 2020 the PS&AW projection increases at a faster rate. By 2020 the PS&AW projection indicates 37 percent more employment and 53 percent more population. The difference can be attributable to the difference in assumptions, methodology, and judgement that were utilized in the projection process. These projections and a comparison of assumptions and methodology used in their derivation are discussed in Appendix IV, Economic Environment.

OBERS IMPACTS ON THE COMPREHENSIVE PLAN

Population was the major parameter used in the Puget Sound Study in developing projections of the various water and related land resource needs. Conse-

quently, some measure is possible of the impact the OBERS projections would have on the Comprehensive Plan. However, as other parameters, such as value-added, also were used, together with historical trends and judgment, a measure through comparison of alternate population projections can be viewed only as approximate. A detailed re-analysis would be required, with new projections developed for each feature in order to accurately define the impacts on the Plan. This is beyond the scope of this Appendix.

The various projects and programs contained in the Comprehensive Plan were designed to satisfy the projected needs for the target years 1980, 2000 and 2020. Consequently, alternative projections of functional needs would, in many cases, affect the timing of the various programs and projects as well as the overall magnitude of costs estimated for the long-range period. As shown in Table 2-48 there is about a 10 percent difference between the PS&AW and OBERS population projections for 1980. Consequently, had the OBERS projections been employed, the impact on the Comprehensive Plan would have been minimal for the early action program. The benefits and costs of some of the projects scheduled for construction prior to 1980 would be somewhat affected. Future project benefits were correlated with the PS&AW economic projections. Since the PS&AW projections are higher than the OBERS projections in the long range the projected growth in benefits could be greater than would be the case with OBERS projections. Therefore, the economic feasibility of some projects could be reduced somewhat over that shown.

In the long-range period, for the years 2000 and 2020, as indicated in Table 2-48, the difference between the two population projects are significant, with the PS&AW projections being 29 percent and 53 percent higher for the years 2000 and 2020, respectively. Assuming a direct correlation between population and the various functional needs projected on the basis of population these needs would correspondingly be reduced by 22 and 35 percent for 2000 and 2020. The impact of OBERS projections on the long-range portion of the Comprehensive Plan is discussed for each feature as follows:

Municipal and Industrial (M&I) Water Supply

Forecasts of future M&I use were based upon population and value-added projections. Municipal and industrial use is projected to increase approximately 133 percent between 1980 and 2020 as compared to a 150 percent increase in population (PS&AW) over this same period. Assuming a direct correlation with population the following forecasts of M&I needs would result from employing OBERS population projections:

Projected Water Use—Puget Sound Area (MGD)

Year	OBERS	PS&AW
1980	1,150	1,278
2000	1,578	2,023
2020	2,053	3,159

The effects on the long-range portion of the Comprehensive Plan would be to shift some M&I projects scheduled for construction before the year 2000 to after that year. As shown in the tabulation above the 2020 M&I use under OBERS is slightly less than the 2000 M&I use under PS&AW. Consequently, projects planned for construction between 2000 and 2020 would not be included in the Comprehensive Plan. Accordingly the overall M&I investment costs could be reduced by about $190,000,000 over that shown in Table 2-30.

Irrigation

Irrigation projections were based upon estimated needs for food and fiber, location and extent of potentially irrigable lands, urban encroachment, historical trends, and the availability of adequate water supplies. These factors limit the acreage which could economically be irrigated.

Population projections, only in their relationship to land use encroachment, were a consideration in the irrigation projections. As less urban land would be required under OBERS projections, the amount of irrigated land could be somewhat greater than presently projected. However, the incremental difference would be minimal since the principal potential irrigated areas near urban centers would have been taken out of production by 1980 under either base study. Consequently, the forecasts developed in the PS&AW Study are considered to be reflective of the needs as would be contained if the OBERS projections were employed.

Water Quality Control

Projections of municipal and industrial wastes were based upon population and value-added, with

the assumption made that additional pulp production required for paper and allied products would be of the Kraft process. Raw wastes from the paper and allied products industry account for about 90 percent of the total current wasteload in the Puget Sound Area. Total raw (before treatment) wastes are projected to increase approximately 53 percent between 1980 and 2020 as compared to a 150 percent increase in population. Projected unit wasteloads of the Kraft process pulp production are assumed to decrease from 30 lbs. BOD/ton in 1980 to 20 lbs. BOD/ton by 2020. Assuming the 1980 level of wasteloading would be the same under the OBERS projections and allowing for 11,000,000 PE wasteload from continuation of existing sulfate process pulp and paper plants and a direct correlation with population on the balance of the wasteloads generated in the Area the following wasteloads are forecast on the basis of OBERS projections:

Projected Municipal and Industrial
Wasteloads–Puget Sound Area
(Population Equivalents)

Year	OBERS	PS&AW
1980	18,524,000	18,524,000
2000	20,561,000	23,587,000
2020	22,193,000	28,943,000

The effects on the long-range portion of the Comprehensive Plan would be to shift expenditures of some funds required for treatment and collection facilities from the 1980-2000 period to the 2000-2020 period. As shown in the tabulation above, the 2020 wasteloads under OBERS are slightly less than the 2000 wasteloads under PS&AW. Consequently, Water Quality Control investments could be reduced by approximately $508,000,000 the amount scheduled for 2000-2020. The impact merely translates into the 1980-2000 investment being spread over 1980-2020.

Navigation

Future waterborne commerce tonnages for the Puget Sound Area were projected by employing a linear regression model based on correlations between commerce and gross national product. The gross national product projections for 1980, 2000 and 2020 used in the PS&AW Economic Study were employed in the regression model to develop estimates of future levels of waterborne commerce in the Area. A comparison of the GNP projections used in the PS&AW Study, converted to 1958 dollars, with those used in the OBERS studies indicates that the OBERS projections are about 5 percent higher in 1980 than the PS&AW projections, with the difference diminishing to approximately half of 1 percent for the year 2020. As a result of the small difference in GNP projections, the projections of waterborne commerce under the OBERS criteria would be expected to be essentially the same as that developed in the PS&AW Study.

The requirements for deep and shallow draft navigation channels and land area for terminal and water transport-oriented industries were based on national trends in vessels and trends in land use. The Navigation Study assumed that a representative cross-section of the world's fleet would be sailing into Puget Sound waters over the 50-year study period. Consequently, the schedule of harbor and channel projects and associated costs contained in the Comprehensive Plan would not be affected by the OBERS projections.

Small boat harbor needs as developed from the Navigation Study were related to projections of wet moorages. The wet moorage needs were projected from a 1966 base derived from a questionnaire survey of Puget Sound pleasure boaters. The PS&AW population growth rates, with the addition of a 1 percent allowance for accelerated interest in pleasure boating and other factors, were used to arrive at the pleasure boat ownership growth rate. This in turn was assumed to equal the wet moorage needs growth rate. Tabulated below is a comparison of wet moorage needs as derived under the PS&AW Study with that derived from the OBERS population projections:

Projected Wet Moorage Needs
Puget Sound Area
(Wet Moorages)

Year	OBERS	PS&AW
1980	42,200	43,800
2000	70,000	79,900
2020	113,400	143,400

An examination of the above wet moorage needs indicate the relatively minor reduction in the projected wet moorage needs for the Puget Sound

Area of about 11 percent for the year 2000 and of about 20 percent for the year 2020. The effects on the long-range portion of the Comprehensive Plan would tend to be minimal. The wet moorage needs for the populous Cedar-Green and Puyallup Basins were not satisfied by the Comprehensive Plan with a residual need of about 17,000 wet moorages projected by 2020. Consequently, little or no impact on small boat harbors contained in the Comprehensive Plan would be expected from use of the OBERS projections.

Power

Electric power requirements in the long-range period were forecast on the basis of Pacific Northwest regional power study growth rates as forecast by the Pacific Northwest Utilities Conference Committee. Consequently, the population projections for the Area do not enter directly into the development of the future power requirements in the long-range period for the Puget Sound Area. The electric power requirements are projected to increase approximately 728 percent between 1980 and 2020 as compared to the 150 percent increase in population. The projected electric power requirements of the Area under the OBERS criteria would be the same as that developed in the PS&AW Study.

Satisfaction of future Puget Sound Area power requirements is dependent upon additional importation of power from outside the Area as well as power production that can be generated within the Area. Consequently, there would be no impact on power development as scheduled in the Comprehensive Plan from employment of the OBERS projections in any case.

Flood Control

Future flood damages projected for the 1980 development level were derived from a 1966 base and employment of annual growth rates from various economic parameters. The growth rates of the four components of future annual damages agriculture, building and equipment, transportation facilities, and other were correlated with population, value-added for select industries, and trends in agricultural production. The long-range levels of flood damage projected for 2000 and 2020 are primarily based on extension of trends developed in projecting the 1980 level of flood damages with allowances made for urban encroachment on agricultural lands. Future flood damages are projected to increase approximately 227 percent between 1980 and 2020.

As a number of factors were considered in projecting the future flood damages a comparison of damages under the OBERS criteria can only be considered approximate. However, the forecasts shown below, which are derived by reducing the PS&AW projected flood damage levels for 2000 and 2020 by the percent differences in population projection, are considered to be reasonable estimates of the future levels of flood damages that would result from using OBERS projections.

Projected Average Annual
Flood Damages
Puget Sound Area ($1000)

Year	OBERS	PS&AW
1980	10,560	10,560
2000	14,320	18,360
2020	22,451	34,530

Employment of the OBERS projections would have limited effects on flood control features of the Comprehensive Plan. Most flood control projects contained in the Plan are scheduled for construction prior to the year 2000. A reduction in the average annual benefits of the early action projects could occur as the incremental benefits derived from property and land value growth would be less under the OBERS projections. However, the benefit reductions would probably be relatively minor.

Watershed Management

The future needs for watershed management were related to the PS&AW population projections. The needs for food and fiber were based on national projections. Therefore, employment of the OBERS projections would not have affected acreage requirements for food and fiber.

Using the OBERS population projection for 2020 would result in a reduction of urban water management improvement needs from 1,040,300 acres to 773,000 acres as shown in the tabulation below:

Projected Urban Water Management
Puget Sound Area
(Acres)

Year	OBERS	PS&AW
1980	711,700	731,400
2000	719,500	799,500
2020	773,000	1,040,300

The reduction of 267,300 acres of land requiring urban water management for 2020 would not affect cropland reduction projections. Instead that acreage of forest land lost to urban development would be reduced. The cost of urban water management would be approximately $26,000,000 less for 1980, $108,000,000 less for 2000 and $361,000,000 less for 2020 over that schedule in the Comprehensive Plan.

Recreation

Future recreation demand was forecast from a 1960 base. An estimate was made of the population seeking outdoor recreation opportunities in the Puget Sound Area. The 1960 participating population was projected to grow at the rate developed from PS&AW population projections for 1980, 2000 and 2020. Future recreation demand is projected to increase approximately 257 percent between 1980 and 2020 as compared with 150 percent increase in population. The difference in percent increase is a result of projected increases in participation rates in the various outdoor recreation activities. Since future recreation demand is directly correlated with population, the impact from OBERS projections on recreation demand can be easily demonstrated, as shown below:

Projected Recreation Demand
Puget Sound Area
(1000 Visitor Days)

Year	OBERS	PS&AW
1980	43,380	48,200
2000	72,460	92,900
2020	111,930	172,200

As shown in the tabulation above, the recreation demand as projected under OBERS would have a 22 percent and 35 percent reduction over the demand forecast in the PS&AW Study for the years 2000 and 2020, respectively. Although the investment costs for the various time periods would not be reduced exactly by the same percentage difference in population projection, this approximation will suffice for purposes of comparison. Accordingly, the Comprehensive Plan costs for campgrounds, picnic areas, beaches, swimming pools and boating facility developments would be reduced by about $101,000,000 and approximately $267,000,000 for the 1980-2000 and 2000-2020 periods, respectively, over that shown in Table 2-30.

Fish and Wildlife

Future demands for fish and wildlife (user-days) were projected on the basis of population forecasts. The fish and wildlife demands were projected in three categories: hunting, sport fishing, and commercial fishing. The hunting demand is projected to increase approximately 100 percent between 1980 and 2020, the sport fishing demand 260 percent, and the commercial fishing demand 79 percent. As these projections were directly correlated with population forecasts for the Puget Sound Area a fairly accurate measure is possible of future fish and wildlife demands under OBERS, as shown below:

Projected Sport Hunting
Puget Sound Area
(1000 User-Days)

Year	OBERS	PS&AW
1980	1,471	1,635
2000	2,068	2,651
2020	2,126	3,271

Projected Sport Fishing
Puget Sound Area
(1000 User-Days)

Year	OBERS	PS&AW
1980	8,540	9,489
2000	11,891	15,245
2020	15,955	24,546

Year	OBERS	PS&AW
	Projected Commercial Fishing Puget Sound Area (1000 lbs)	
1980	47,308	52,565
2000	56,299	72,178
2020	61,085	93,977

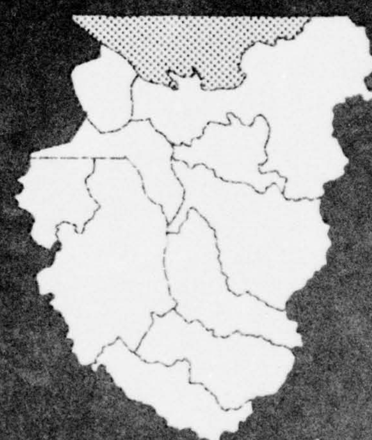
Projected fish and wildlife demands as shown above would be reduced under the OBERS projections 22 and 35 percent over those shown for PS&AW for the years 2000 and 2020, respectively. As shown in the tabulation above the 2020 fish and wildlife activity under OBERS is nearly the same as the 2000 activity under PS&AW. Consequently, fish and wildlife investments could be reduced by approximately $123,000,000, the amount scheduled for 2000-2020 in Tables 2-29 and 2-30. The impact merely translates into the 1980-2000 investment being spread over 1980-2020.

Summary

The methodology employed in making the OBERS projections is a function of what happens in the Nation with a disaggregation of national totals into over 200 subregions; whereas the PS&AW Study concentrated on only one region. The PS&AW Study with an intense investigation of the Area has the capability of taking more economic growth factors into consideration. The role of different statistical methods and the substantial judgments employed in each of the two separate economic studies both contributed to the divergent projections. Consequently, the periodic and systematic updating of the Comprehensive Plan should consider the economic growth that has occurred in the interim period. The next review study would have the benefit of data developed from the 1970 census and therefore, a more accurate indication of the true direction of the local economy would be available for use in updating studies. Perhaps the actual growth of water and related land resource needs of the Area will fall somewhere in between the PS&AW and OBERS projections. These two alternative projections are considered to form an envelope in which the true values probably lie somewhere within.

The overall impact of OBERS economic projections on the Comprehensive Plan would be primarily on those functions where future needs were closely related to population growth. These were municipal and industrial water supply, water quality control, recreation, and fish and wildlife. The approximate reduction in investment costs over the 50-year study period would be about $1,684,000,000 with most of this reduction occurring in the 2000-2020 period.

Nooksack-Sumas Basins



NOOKSACK—SUMAS BASINS

DESCRIPTION OF BASINS

GENERAL

The Nooksack-Sumas Basins, lying adjacent to the Canadian Border, comprises 1,243 square miles of land, 19 square miles of fresh water and 366 square miles of saltwater. The Nooksack Basin and coastal streams drain into Bellingham Bay and the Sumas Basin drains into the Fraser River to the Strait of Georgia. The North Fork, the largest tributary of the Nooksack River drains 293 square miles, the Middle Fork drains 102 square miles, and the South Fork drains 183 square miles and the main stem and Lummi Rivers drain 248 square miles. The Sumas River drains a total of 143 square miles, of which 73 are within the United State and 70 in Canada.

Of the eleven basins in the Puget Sound Area, the Nooksack-Sumas ranks fourth in runoff with an average of 3,700,000 acre-feet flowing into Puget Sound annually. Of this total 2,750,000 acre-feet is supplied by the Nooksack River. Ground water in the lowlands is estimated to receive an average of 50,000 acre-feet if recharged annually.

The orographic lifting of the moist maritime air on the windward foothill slopes and higher elevations of the Cascades results in an annual precipitation increase from about 32 inches at the mouth of the Nooksack River to more than 100 inches at Mount Baker. Approximately 50 percent of the annual precipitation falls during the four months of October through January, and 75 percent from October to March. As the more intense weather systems move inland, 3 inches of precipitation in 24 hours may be expected once each 5 years on the lowlands as compared to 6 inches on the mountain west slopes and foothills. Average winter snowfall ranges from less than 10 inches near the Sound to 515 inches at Mount Baker.

Streamflow characteristics and other data related to hydrology of the Basin are discussed in detail in Appendix III, Hydrology and Natural Environment. The physiographic characteristics and soil properties are given in Appendix V, Water-Related Land Resources.

PRESENT SITUATION

Local Economy

The population of the Basins was estimated to be 77,300 in 1967. Bellingham, the largest city, had a population of 36,500. Industrial expansion has been an important factor in recent population growth. A total of 7,800 people reside in Blaine, Everson, Ferndale, Lynden, and Sumas. The remaining population are clustered in rural nonagricultural and rural areas. Historical population statistics are tabulated in Table 3-1.

TABLE 3-1. Historical population, Nooksack-Sumas Basins

	1940	1950	1960	1967
Nooksack-Sumas Basins	60,400	66,700	70,300	77,300
Principal cities and towns:				
Bellingham	29,314	34,112	34,688	36,500
Lynden	1,696	2,161	2,542	2,850
Ferndale	717	979	1,442	1,850
Blaine	---	---	---	1,800
Sumas	650	658	629	674
Everson	292	345	431	625

Source: Appendix IV, Economic Environment, Appendix V, Water-Related Land Resources.

An oil refinery and an aluminum plant were constructed in 1954 and 1963 respectively. Light industries including food processing, fishing, canning, logging, wood processing and operation of port facilities are the principal employers of non-agricultural works. The Basin's proximity to deep salt water is important with Bellingham Harbor accommodating vessels serving foreign and domestic shipping.

Land Use

Within the Nooksack-Sumas Basins there are 792,300 acres of land. The present land use is tabulated in Table 3-2 and shown in Figure 3-1.

TABLE 3-2. Present land use, Nooksack-Sumas Basins

Land Use	Acres	Percent
Cropland	137,500	17.4
Rangeland	11,600	1.5
Forest[1]	609,600	76.9
Rural non-farm	12,700	1.6
Intensive	20,900	2.6
Total	*792,300*	*100.0*

[1] Includes alpine and other nonforested lands normally associated with forest.

Source: Appendix V, Water-Related Land Resources.

Forests are the largest use of the land with 76.9 percent in this category. Croplands, which account for 17.4 percent of the land use, are largely located on the fertile bottomlands of the Nooksack and Sumas Rivers. Approximately 78 percent of the present cropland is in forage production and the remainder is used for peas, vegetables, berries, potatoes and miscellaneous specialty crops.

The intensive land use in the Nooksack-Sumas Basins consists of residential areas, industrial development, commercial development, public and semi-public uses and reserved open space. The intensive land use (see Appendix V, Water-Related Land Resources) is distributed in acres as follows: railroads 700, roadways 5,000, airports 300, and urban (built-up) 15,000 for a total of 21,000 acres.

The major areas of intensive use are around Bellingham, Blaine, and west of Ferndale where the Intalco Aluminum Reduction Plant and the Mobile Oil Refinery may mark the beginning of a large industrial complex. The shorelines of Birch Bay, south of Blaine, and around Lake Whatcom are rapidly developing as residential, resort and recreation areas. Ferndale, Bellingham, and Lynden support processing plants for agricultural products.

Land ownership distribution is shown in Table 3-3.

TABLE 3-3. Land ownership, Nooksack-Sumas Basins

Ownership	Percent
Private	39.7
Private corporate	14.4
Federal	34.3
State	10.7
Local government	0.9
Total	100.0

Source: Appendix V, Water-Related Land Resources.

PROJECTED ECONOMY AND LAND USE

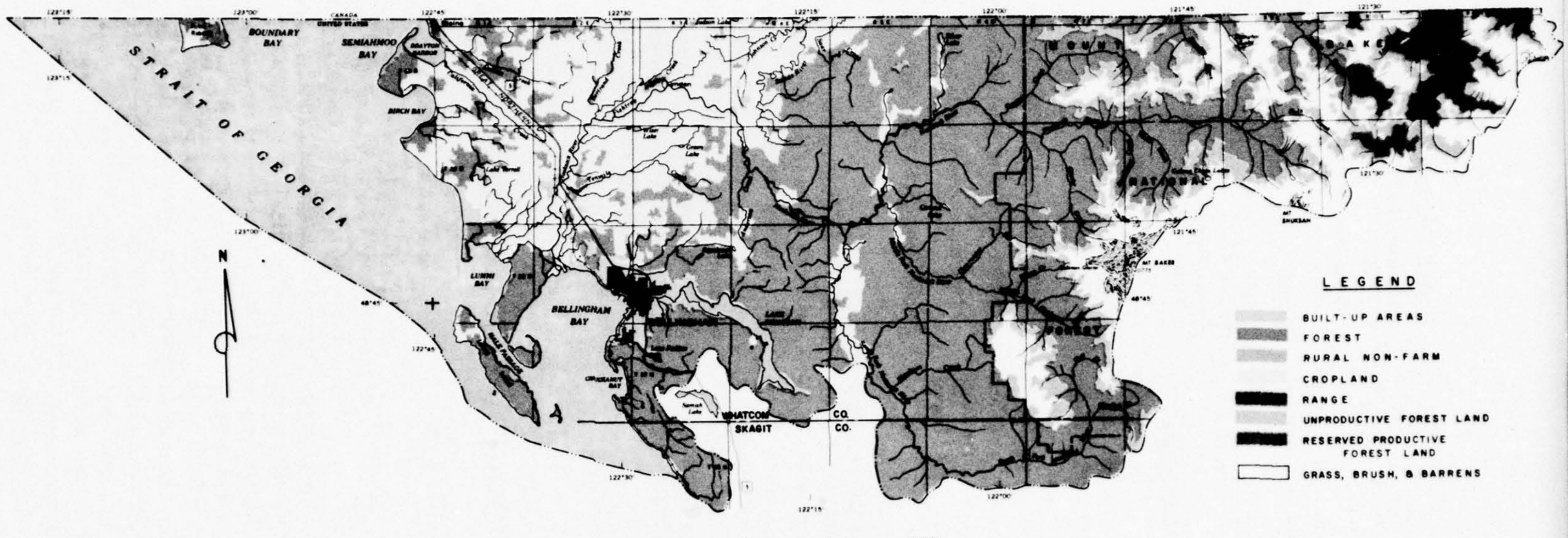
Local Economy

Table 3-4 presents a forecast of population, employment and gross regional product for the Northern Division and the projected population for the Nooksack-Sumas Basins. These forecasts are translated into average annual growth trends.

TABLE 3-4. Economic projections, Nooksack-Sumas Basins

					Average Annual Growth Trends (Percent)			
	1963	1980	2000	2020	1963 to 1980	1980 to 2000	2000 to 2020	1963 to 2020
North Division								
Population (1000's)	151.0	185.5	249.9	341.5	1.2	1.5	1.6	1.4
Employment (1000's)	45.5	57.9	78.2	106.7	1.4	1.5	1.6	1.5
GRP (Million $'s)	369.1	848.4	1,799.7	3,902.4	5.0	3.8	4.0	4.2
Nooksack-Sumas Basins								
Population (1000's)	74.6	91.6	123.5	168.7	1.2	1.5	1.6	1.4

Source: Appendix IV, Economic Environment; Appendix V, Water-Related Land Resources.



NOOKSACK-SUMAS BASINS
GENERALIZED LAND USE MAP

FIGURE 3-1.

The large growth industries in this area are aluminum, primary metals, pulp and paper, and government. A combination of (1) waterfront facilities for developing international and intercoastal trade, (2) proximity to Vancouver B.C. and (3) opportunities to satisfy a growing market contribute to future growth.

Future Land Use

The projected land use of the Nooksack-Sumas Basins for 2020, shown on Figure 3-2 is compared in Table 3-5 with 1967 land use. This land use pattern is based on the construction of a cross-Sound bridge and a bridge between the mainland and southern Whidbey Island. (Alternative C_2 in Appendix V, Water-Related Land Resources). The intensive land use density for the Nooksack-Sumas Basins is forecast to increase from 3.6 persons per acre to 5.7 persons per acre by 2020.

In the year 2020 a population increase of 2.3 times the present population would require a increase in intensively used land by about 9,000 acres, or 1.5 times the present amount. This acreage would come from conversion of land now in forest, cropland and rural non-farm uses. Forest lands would decrease by 1 percent, rural nonfarm land by 5 percent, and cropland by 5 percent. Some development within the flood plain is expected. However, early implementation of flood plain zoning would provide a means of restricting intensive development.

TABLE 3-5. Present and projected[1] land use, Nooksack-Sumas Basins (acres)[2]

Land Use	1967	1980	2000	2020
Forest	609,600	607,600	605,600	604,600
Range	11,600	11,600	11,600	11,600
Cropland	137,500	137,100	136,100	134,200
Rural non-farm	12,700	12,500	12,300	12,100
Intensive	20,900	23,500	26,700	29,800
Total	792,300	792,300	792,300	792,300
Population	77,300	91,600	123,500	168,700
Density[3]	3.6	4.0	4.6	5.7

[1] Alternative Land Use Pattern C_2, see Puget Sound Area.

[2] Figures rounded to nearest hundred.

[3] Persons per intensive land use acre.

Source: Appendix V, Water-Related Land Resources.

Intensive development is expected to expand in the Ferndale, Sumas and Everson areas, parts of which are subject to periodic flooding. The residential areas supporting the industrial complex west of Ferndale are expected to develop on the rolling hills west of Ferndale, along the Birch Bay area, Bellingham and Blaine.

WATER AND RELATED LAND RESOURCE NEEDS

MUNCIPAL AND INDUSTRIAL WATER SUPPLY

General

The city of Bellingham, the largest single water user in the Basins, relies primarily on water from the Middle Fork of the Nooksack River during the low flow period. Water is diverted through a 10-mile pipeline into Mirror Lake, from where it flows down Anderson Creek into Lake Whatcom. Bellingham filters Lake Whatcom water for its domestic supply. The present capacity of the Middle Fork pipeline is 95 cfs, approximately equal to the average daily demand. The city of Lynden diverts its water supply from the Nooksack River at Lynden. Treatment prior to distribution includes filtration and disinfection.

The city of Ferndale obtains its water supply from wells. Water is provided without treatment to an estimated 16,000 people. Many small, cooperative water systems have been formed in areas where ground water is deep and expensive to reach on an individual basis, or where iron concentrations in the ground water supplies are objectionable. These rural systems serve much of the area surrounding Lynden and to the west of Ferndale. Approximately 4,460 individual water systems within the basins serve approximately 15,700 people. About 90 percent of these systems use ground water as a source of supply.

Industry uses about 83 percent (60.6 mgd) of all water consumed in the Basin. Whatcom County Public Utility District No. 1 provides industrial water

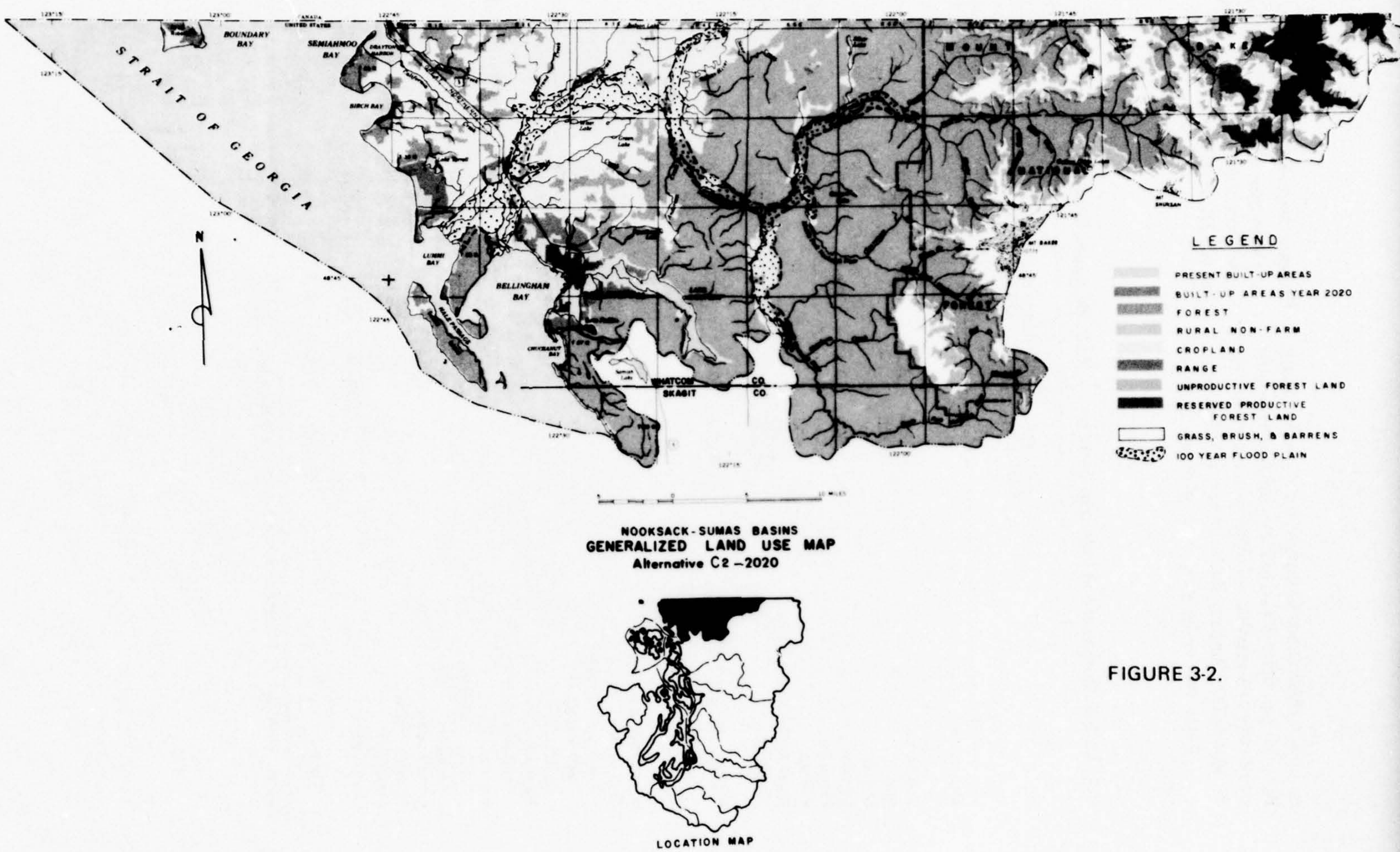

STRAIT OF GEORGIA
BOUNDARY BAY
SEMIAHMOO BAY
BIRCH BAY
LUMMI BAY
BELLINGHAM BAY
CHUCKANUT BAY
WHATCOM CO
SKAGIT CO
CANADA
UNITED STATES
N
LEGEND
PRESENT BUILT-UP AREAS
BUILT-UP AREAS YEAR 2020
FOREST
RURAL NON-FARM
CROPLAND
RANGE
UNPRODUCTIVE FOREST LAND
RESERVED PRODUCTIVE FOREST LAND
GRASS, BRUSH, & BARRENS
100 YEAR FLOOD PLAIN
NOOKSACK-SUMAS BASINS
GENERALIZED LAND USE MAP
Alternative C2 –2020
LOCATION MAP

FIGURE 3-2.

to Intalco Aluminum Company from the Nooksack River at Ferndale. All large industrial water supplies are obtained from publicly-owned systems, except for the Mobile Oil Company Refinery near Ferndale.

Water use in the year 1965 is shown in Table 3-6.

Present and Future Needs

Municipal and Industrial water use is projected to rise from the 1965 level of about 73 mgd to 293 mgd in 2020 as shown in Table 3-7.

TABLE 3-6. Municipal and industrial water use in 1965, Nooksack-Sumas Basins

System	Estimated Population Served	Surface water usage (mgd)			Ground water usage (mgd)		
		Average Daily	Maximum Monthly	Maximum Daily	Average Daily	Maximum Monthly	Maximum Daily
MUNICIPAL USE							
Bellingham	40,000	8.90	12.50	25.20	---	---	---
Blaine	4,200	---	---	---	0.47	0.55	0.65
Sumas	3,200	---	---	---	0.39	0.72	1.05
Lynden	2,600	0.40	0.80	1,20	---	---	---
Ferndale	1,600	---	---	---	0.25	0.37	0.50
Everson	600	---	---	---	0.11	0.25	0.16
Rural community systems	7,200	---	---	---	0.54	0.85	1.16
Subtotal	59,400	9.30	13.30	26.40	1.90	2.60	3.52
RURAL–INDIVIDUAL USE	18,300	0.10	0.20	0.30	0.90	1.30	1.80
INDUSTRIAL USE							
Municipally supplied:							
Bellingham							
Food and kindred		0.96	1.35	1.64	---	---	---
Paper and allied		46.40	50.50	54.00	---	---	---
Other		0.75	0.80	0.84	---	---	---
Ferndale							
Food and kindred		---	---	---	0.32	0.85	1.40
Lynden							
Food and kindred		0.21	0.31	0.41	---	---	---
Self-supplied							
Food and kindred		0.76	1.00	1.22	0.23	0.35	0.60
Primary metals		8.00	8.00	8.00	---	---	---
Petroleum		2.80	2.80	2.80	---	---	---
Subtotal		59.88	64.76	68.91	0.55	1.20	2.00
Total	77,700	69.3	78.3	95.8	3.40	5.10	7.30

Source: Appendix VI, Municipal and Industrial Water Supply.

TABLE 3-7. Projected municipal and industrial water needs, Nooksack-Sumas Basins

Year	Use	Total (Avg. Daily M.G.D.)	Total (1,000's A.F. Annually	Net Needs[1] M.G.D.	Net Needs[1] (1,000's Acre-Feet)
1965	Municipal	11.2	12.5		
	Industrial	60.4	67.6		
	Rural-Individual	1.0	1.1		
	Total	72.6	81.2		
1980	Municipal	14	15.7		
	Industrial	141	157.9		
	Rural-Individual	1	1.1		
	Total	156	174.7	83	93.5
2000	Municipal	22	24.6		
	Industrial	188	210.2		
	Rural-Individual	2	2.2		
	Total	212	237.0	139	155.8
2020	Municipal	33	37.0		
	Industrial	257	287.8		
	Rural-Individual	3	3.4		
	Total	293	328.2	220	247.0

[1] Cumulative total above 1965 use.

Source: Appendix VI, Municipal and Industrial Water Supply.

IRRIGATION

General

The Basin contains about 110,500 acres of potentially irrigable lands, of which 38,400 acres are presently irrigated. Most of the presently irrigated lands are located in the lowlands along the Nooksack River, the Sumas River, and the benchlands north of Lynden. About 65 percent of the irrigated lands were supplied by ground water in 1967. As of April 1967, surface water diversion was approximately 120 dfs. Irrigation ground water rights as of September 1966, totaled approximately 180 cfs.

Present and Future Needs

About 40,000 acres of land, primarily located in the valley below Deming, have a potential for irrigation. Estimates indicate that 20,000 acres would be irrigated by 1980, and the remaining 20,000 acres by the year 2000. Projected irrigation development to 1980 is forecast to follow present trends whereby individual farm units are placed under irrigation each year. The units would be scattered throughout the Basins and development would be primarily by private means.

Present and future irrigation needs are shown in Table 3-8.

The monthly distribution of the irrigation requirements are shown as a percent of the annual demand.

June	22%	August	28%
July	37%	September	13%
		Total	100%

WATER QUALITY CONTROL

General

The chemical quality of surface waters in the Nooksack-sumas Basins is generally excellent. Total dissolved solids concentrations for the surface waters of the Basins rarely exceeds 100 mg/l. The water in all streams generally is soft, normally having hardness levels of 60 mg/1 or less.

The bacteriological quality of the Nooksack River is satisfactory, for the most part, but there is a

TABLE 3-8. Irrigation present status and projected needs, Nooksack-Sumas Basins

Year	New Irrigation (acres)	Total Irrigation (acres)	Total Annual Diversion (acre-feet)	Net Needs[1] (acre-feet)
1966		38,400	73,000	---
1980	20,000	58,400	111,000	38,000
2000	20,000	78,400	149,000	76,000
2020		78,400	149,000	76,000

[1] Cumulative annual diversion above 1966 use.

Source: Appendix VII, Irrigation.

general trend of decreasing quality from the headwaters to the mouth. The higher concentrations of coliform bacteria usually occur during the summer months in stream reaches below the more populated areas. Dissolved oxygen concentrations throughout the river's length normally are near saturation.

The turbidity of the Nooksack River is high when compared to other streams on the east side of Puget Sound. This is caused primarily by the substantial quantities of glacial silt.

Water quality in and around Bellingham Harbor is presently substandard for varying distances from points of waste discharge. Allowable dilution areas are being defined as part of the State-Federal water quality programs initiated under the Clean Waters Restoration Act of 1965.

The peak municipal and industrial wasteloads generated in the Nooksack-Sumas Basins approximates over two million population equivalents, of which only six percent are presently removed by treatment before discharge to fresh and marine waters. More than 90 percent of the total raw wasteload is produced in the Bellingham Service Area on Bellingham Bay. About seven percent is produced in areas along the Nooksack River. Waste generation, treatment and discharges for the 1965 year are shown in Table 3-9.

Present and Future Needs

State-Federal water quality standards provide the baseline from which present and future needs for water quality control are determined. The water quality classification established by the State for each watercourse in the Basins is outlined in Appendix XIII, Water Quality Control.

Present water quality control needs are concentrated primarily in marine waters, where fish processing, pulping, and municipal waste discharges create unsatisfactory water quality conditions.

Water quality problems exist in the lower Nooksack River. High concentrations of coliform organisms in the lower reaches of the river are thought to be caused by waste discharges from the Ferndale, Lynden, and Everson areas. The lower Nooksack River flood plain, however, is used extensively for dairying, and the wastes produced by livestock may be significant contributors to the coliform concentrations in the river.

High coliform concentrations occur near Lake Whatcom's outlet. Otherwise the water quality of the Lake is generally excellent. Coliform concentrations in Lake Whatcom are believed to originate from septic tank effluents of lakeshore residents. Projected wasteloading is presented in Table 3-10.

TABLE 3-9. *Summary of municipal and industrial wastes, Nooksack-Sumas Basins, 1965*

Watercourse	Estimated Population Served	Non-Seasonal Untreated Waste PE	Seasonal Untreated Waste PE	Treatment	Non-Seasonal Waste Discharge PE	Seasonal Waste Discharge PE
Boundary Bay						
Food and Kindred	--	2,800	600	None	2,800	600
Drayton Harbor						
Blaine	1,700	2,200	--	Primary	2,200	--
Food and Kindred	--	1,450	--	None	1,450	--
Blaine A.F.B.	350	350	--	Secondary	50	--
Birch Bay						
Birch Bay State Park	--	1,000	--	Primary, Individual	--	--
Georgia Strait						
Oil Refining	--	1,000	--	Secondary	600	--
Bellingham Bay						
Bellingham-Harris St. Outfall	1,600	2,000	--	None	2,000	--
Food and Kindred	--	50,000	58,600	None	50,000	58,600
Paper and Allied	--	1,687,000	--	None	1,687,000	--
Whatcom Creek						
Bellingham	30,000	47,000	--	Primary	27,300	--
Food and Kindred	--	5,500	--	City	3,200	--
Squalicum Creek						
Fairhaven Outfall	2,600	2,600	--	None	2,600	--
Nooksack River						
Lynden	2,700	2,700	--	Secondary	500	--
Food and Kindred	--	--	4,500	Secondary	--	700
Food and Kindred	--	19,000	25,000	None	19,000	25,000
Everson	300	300	--	Primary, Individual	--	--
Food and Kindred	--	--	70,500	Lagoon	--	17,000
Food and Kindred	--	1,100	--	None	1,100	--
Ferndale	1,450	1,500	--	Primary	1,200	--
Food and Kindred	--	--	30,000	Lagoon	--	3,000
Hospital	--	350	--	Secondary	100	--
Sumas River						
Sumas	500	600	--	Primary	200	--
TOTAL	41,200	1,830,000	189,000	--	1,800,000	105,000
Municipal	41,200	60,000	--	--	36,000	--
Industrial	--	1,770,000	189,000	--	1,765,000	105,000

Source: Appendix XIII, Water Quality Control.

TABLE 3-10. Present and projected raw wasteloadings, Nooksack-Sumas Basins (1000's P.E.)

Year	Municipal	Industrial	Recreational	Total	Net Needs[1]
1965	60	1,951	20	2,031	1,910
1980	92	2,979	31	3,102	2,981
2000	128	3,440	56	3,624	3,503
2020	179	3,805	103	4,087	3,966

1 Cumulative raw wasteload requiring treatment above that receiving treatment in 1965.

Source: Appendix XIII, Water Quality Control.

NAVIGATION

General

Bellingham is the principal harbor in the Nooksack-Sumas Basins and is located at the head of Bellingham Bay. The harbor is about 108 nautical miles from the Pacific Ocean. The harbor accommodates craft transporting general cargo, forest products, petroleum, dry bulk and liquid bulk in foreign import and export, as well as coastwise transport of these products. Channel depths of over 60 feet are available in the Bay; however, the flat slopes near the shorelines have made it necessary to dredge channels to the wharves.

Blaine Harbor is on the east side of the entrance to Drayton Harbor located approximately 20 miles north of Bellingham and about 112 nautical miles from the Pacific Ocean. There are eight marinas in the Basins providing public and private rental moorage facilities.

Present and Future Needs

The major problem in the Bellingham Harbor is the requirement for periodic dredging to remove the silt brought in by the Nooksack River. The delta areas of the river have a potential for the development of industrial and terminal sites. The major problem is the control of silting and the maintenance of an adequate floodway.

Lands for waterfront terminals and water transport-oriented industry are expected to increase from about 900 acres in 1963 to 5,879 acres by the year 2020. Future land needs for terminal facilities and water-transport-oriented industries are dependent upon the economic growth of the Area as well as these Basins.

Protected wet moorage development would be required to meet current and future pleasure boat needs. Pleasure boat needs and projected waterborne commerce are shown in Table 3-11.

TABLE 3-11. Projected pleasure boating needs and waterborne commerce, Nooksack-Sumas Basins

Small Boat Wet Moorages			Waterborne Commerce (1000's Short Tons)		
Year	Total	Net Needs[1]	Year	Total	Net Needs[2]
1966	710	496	1963	1,500	--
1980	990	776	1980	4,700	3,200
2000	1,620	1,406	2000	13,000	11,500
2020	2,700	2,486	2020	29,400	27,900

1 Cumulative needs above the 214 wet moorages available in 1966.

2 Cumulative waterborne commerce above total for 1963.

Source: Appendix VIII, Navigation.

Extensive tide flats in Bellingham Bay would require the dredging of channels to service terminal facilities. Additional industrial lands would be required to accommodate demands. Table 3-12 shows harbor and channel requirements and terminal and industrial land needs.

TABLE 3-12. Harbor and channel and terminal and water transport-oriented industrial land requirements, Nooksack-Sumas Basins

	Harbor and Channel Req. (vessel draft in feet)			Terminal and Industrial Land	
Year	Freighters	Bulk Carriers	Tankers	Total	Net Needs[1]
1963	---	---	---	900	---
1980	35	35	98	2,000	1,100
2000	40	71	104	3,500	2,600
2020	40	71	104	5,900	5,000

1 Cumulative needs above 1963 land use.

Source: Appendix VIII, Navigation.

POWER

General

Power developments in the Nooksack-Sumas Basins consists of one small hydropower plant owned by the Puget Sound Power and Light Company at the foot of Nooksack Falls on the North Fork of the Nooksack River. It is a run-of-the-river plant with the intake diversion at the head of the falls. The plant has an installed capacity of 1,500 kilowatts. Additional power needs are purchased from outside sources, mainly the Bonneville Power Administration.

Present and Future Needs

The energy needs are expected to move even faster than the rate of population expansion. Additional power generation and transmission facilities would be required to meet these needs. There are a number of sites in the Basins having a potential for hydroelectric power development. These include pumped-storage sites as well as multiple-storage sites where power could be provided as an additional project purpose.

Thermal nuclear power plants would be required in addition to power supplied from the Pacific Northwest regional system to meet the future needs of Puget Sound Area. (The exact number of nuclear-fired power plants to be located in the Nooksack-Sumas Basins is unknown at this time). Further location and environmental studies must be conducted before specific sites can be selected. Power needs are discussed further in the Area portion of this Appendix.

FLOOD CONTROL

General

The entire valley floor of the Nooksack-Sumas River, from the lower reaches of the North, Middle, and South Forks to its mouth at Bellingham Harbor, comprises the flood plain. The flood plain of the Nooksack-Sumas Basins contains 49,000 acres and varies in width from one-half mile along the upper reaches, to one to three miles in the vicinity of Everson and Lynden, and to more than four miles below Ferndale.

As the flood plain is used primarily for agriculture, the greater part of the flood damage is to lands and crops, resulting from the flooding of grasses, loss of livestock, erosion of banks, and leaching of fertilizers. Next in order of importance are damages to buildings and residences in urban areas and on agricultural lands. Roadways are subject to erosion and weakened conditions resulting from subgrade saturation, which cause delays in traffic.

Flood flows of the Nooksack River inundate much of the cultivated lowlands adjacent to the river below Deming, a large area on the right bank below Ferndale, all the town of Marietta, and portions of the towns of Everson and Ferndale. In addition, extreme high water overtops the low divide between the Nooksack and Sumas Valleys, aggravating flood conditions in the Sumas Basin on both sides of the international boundary. There are 42.4 miles of levee along the Nooksack, 3 to 6 feet in height, that provide varying degrees of protection. These are all likely to be overtopped on an average of every five years. There are no storage reservoirs in the Basin to regulate flows. Average annual flood damages under present conditions are estimated to be $853,000.

Table 3-13 lists the peak discharges and recurrence intervals of recent major floods and 50 and 100-year floods at Deming. Estimated flood damages are based on 1966 prices and conditions.

TABLE 3-13. Major floods and estimated damage, Nooksack-Sumas Basins

	Peak Discharge of Nooksack R. At Demining (cfs)	Average Reoccurrence Interval (years)	Current Estimated Damage
10 Feb 1951	43,200	12	$2,256,000
25 Jan 1935	39,600	9	1,972,000
Estimated	56,600	50	4,149,000
Estimated	63,000	100	5,014,000

Source: Appendix XII, Flood Control.

Present and Future Needs

There is a need to reduce the present average annual flood damages of $853,000 in the flood plain that occurs to croplands, dwellings, roads and utilities in the flood plain. Additional flood control is

desirable to protect the increasingly valuable agricultural investment and urban and industrial developments in the Nooksack-Sumas flood plain. More intensive agriculture is expected in the future with higher value crops produced.

The trend of development within the Basin is expected to result in the future growth of flood damages approximating a rate of 2.0 percent compounded annually without flood control improvements and would result in the future growth of average annual damages to \$1,210,000 in 1980, \$1,970,000 in 2000, and \$3,350,000 in 2020 (see Table 3-14).

TABLE 3-14. Projected flood damage reduction needs,[1] Nooksack-Sumas Basins

Year	Total ($1000)	Net Needs[2] ($1000)
1966	853	853
1980	1,210	1,210
2000	1,970	1,970
2020	3,350	3,350

[1] Based on 1966 prices and conditions.

[2] *Damages which would occur without additional measures.*

Source: Appendix XII, Flood Control.

WATERSHED MANAGEMENT

General

The need in the Nooksack-Sumas Basins is for implementation of integrated programs and projects for floodwater damage reduction and water management, with rehabilitation and protection of watershed lands regardless of use. The implementation of integrated programs and projects would meet the primary objectives, improve the quality of municipal and industrial water, enhance fish and wildlife habitat and opportunities for recreation, and improve the general environment.

Present and Future Needs

The needs for watershed management in some instances require practices or measures to be implemented on the same area of land. Many measures and treatments become involved in integrated programs and projects. The broad needs for improved technology programs and projects are given in the Area discussion. The watershed management needs for the Basins are tabulated in Table 3-15.

TABLE 3-15. *Total watershed management needs,* Nooksack-Sumas Basins

Year	Flood Prevention (acres)[1]	Watershed Protection and Rehabilitation (acres)	Water Management: Agricultural (acres)	Water Management: Urban (acres)
1980	113,000	792,200	55,400	33,600
2000	113,000	792,200	92,300	33,600
2020	113,000	792,200	123,100	33,600

[1] Includes flooding on main streams.

Source: Appendix XIV, Watershed Management.

RECREATION

General

The Nooksack-Sumas Basins are well suited to provide water-related recreational opportunities with many miles of salt water shoreline, lakes and rivers and streams. There are 234,000 acres of salt water, 7,900 acres of lakes and reservoirs, and approximately 63 miles of rivers suitable for boating in the Nooksack-Sumas Basins.

In 1964 there were 75 publicly-administered outdoor recreation areas within the Basin. Of the 357,000 acres of public land classified as available for public visitation, 203,000 acres are within the Mt. Baker National Forest, and 69,000 acres are in the North Cascades National Park. Two of the three State parks in the Basins are located on the saltwater shoreline.

Present and Future Needs

The present and future demand for water-related recreation in the Nooksack-Sumas Basins is expressed in recreation days and shown in Table 3-16.

Additional facilities and acquisition and development of land are required in order to satisfy the needs for water-related outdoor recreation. The existing supply of developed lands was inadequate to satisfy 1960 boating, camping and picnicking needs. In addition to indicated needs, urban parks, scenic

routes, waterfront access, recreation rivers, special interest areas, interpretive facilities, open spaces, and beaches and trails for activities other than swimming and hiking are necessary to satisfy recreation and environmental requirements.

TABLE 3-16. Present and projected water-related recreation demand, Nooksack-Sumas Basins (1000's recreation days)

Year	Total	Net Needs[1]
1960	2,100	600
1980	4,100	2,600
2000	7,800	6,300
2020	14,400	12,900

[1] Cumulative needs above 1,500,000 recreation days satisfied by facilities existing in 1960.

Source: Appendix X, Recreation.

FISH AND WILDLIFE

General

The Nooksack-Sumas Basins contain about 275 miles of river and tributaries accessible for the spawning and rearing of anadromous fish; principally chinook, coho, pink, sockeye and chum salmon; steelhead and cutthroat trout; and searun Dolly Varden. Of the total 275 miles suitable for spawning, 168 miles are in the main-stem of the Nooksack and its three main tributaries. The remainder is in independent drainages and the Sumas River.

Resident fish spawn and rear throughout the fresh waters upstream and downstream from anadromous barriers. Resident fish include rainbow trout, Dolly Varden, brook trout, kokanee, and mixed non-game fish species.

Average stream production within the South Fork drainage is considerably higher than that of either the North Fork, Middle Fork, or main Nooksack River. This is due to headwaters on the North and Middle Forks contributing glacial silt and extremely cold water during the summer growth season. Resident wildlife species inhabit the entire Nooksack-Sumas Basins, with black-tailed deer the most numerous big game animals. Elk, mountain goat and black bear are also present in significant numbers. Upland game, fur animals and waterfowl in significant numbers inhabit the Basins.

Present and Future Needs

There is need to retain and expand fishing opportunities for trout, steelhead, salmon and other species in the Nooksack-Sumas Basins. Similarly, there is a need to provide opportunities for hunting commensurate with the growth in population.

The projected fishing and hunting needs for the Nooksack-Sumas Basins are shown in *Table 3-17*.

TABLE 3-17. Fish and wildlife, sport and commercial needs, Nooksack-Sumas Basins

		1965	1980		2000		2020	
	Unit	Total	Total	Net[1]	Total	Net[1]	Total	Net[1]
Sport Fishing								
Salmon	1000 User-Days	26	41	15	76	50	129	103
Game Fish	1000 User-Days	219	366	147	516	357	922	703
Marine Fish	1000 User-Days	12	17	5	22	10	29	17
Shellfish	1000 User-Days	9	12	3	17	8	21	12
Total		266	436	170	691	425	1,101	835
Hunting	1000 User-Days	75	144	69	234	159	288	213
Commercial Fishing	1000 Pounds			115		2,610		4,278

[1] Cumulative need above 1965 activity.

Source: Appendix XI, Fish and Wildlife.

COMPREHENSIVE PLAN

BASIS OF PLANNING

Desires of Local People

During a public hearing held at Anacortes on 12 October 1964, local interests expressed a desire for improvements to reduce flood damages in the Nooksack-Sumas River Basins, adequate water supply to serve municipal and industrial needs, construction of drainage facilities to permit use of lands for recreation, conservation and housing, cropland use, water quality control and improvements, preservation of salmon spawning areas, consideration of scenic and recreational resources, and retention of wild rivers in their natural state (See Appendix I, Digest of Public Hearings).

Summary of Basin Needs

The needs of the Nooksack-Sumas Basins projected for 1980, 2000 and 2020 are summarized in Table 3-18.

General Planning

A wide range of alternative nonstorage and management opportunities were viewed to meet the

TABLE 3-18. Summary of needs, Nooksack-Sumas Basins

Feature	Units	Cumulative Net Needs[1] 1980	2000	2020
M & I Water Supply	mgd	83	139	220
	(1,000 Acre-ft.)	(93)	(155)	(246)
Irrigation	1,000 Acre-ft.	38	76	76
Water Quality Control				
Waste	1,000 Pop. Equiv.	2,981	3,503	3,966
Flow[2]	cfs	180	350	725
Navigation				
Commercial	1,000 Short Tons	3,200	11,500	27,900
Pleasure Boats	Wet Moorages	780	1,410	2,490
Power[3]				
Flood Control	$1,000 Damage Reduction	1,210	1,970	3,350
Watershed Management				
Flood prevention	1,000 Acres	113.0	113.0	113.0
Watershed prot. and rehab.	1,000 Acres	792.2	792.2	792.2
Water Management				
Agriculture	1,000 Acres	55.4	92.3	123.1
Urban	1,000 Acres	33.6	33.6	33.6
Recreation	1,000 User-Days	2,600	6,300	12,900
Fish and Wildlife				
Sport				
Fishing	1,000 User-Days	170	425	835
Hunting	1,000 User-Days	69	159	213
Commercial Fishing	1,000 Pounds	115	2,610	4,278

[1] See Water and Related Land Resource Needs for derivation of net needs.

[2] Main stem Nooksack River.

[3] Power Needs were projected for the Puget Sound Area only.

water supply needs of the Nooksack-Sumas Basins. These included diversion structures, direct river pumping and treatment, desalinization, interbasin water transfer, further ground water utilization, and improved water yields through various watershed management practices. Levees, channelization, diversion, flood plain management, bank protection, and improved land use management practices were considered as possible means of meeting flood control and watershed management needs. Opportunities considered for satisfaction of water quality needs were sewage collection and treatment facilities and minimum flows available to assimilate residual waste-loadings. The water and related land resource was examined in terms of projected land use pattern C_2, (see Projected Land Use) with the land needs of navigation, power, recreation, open space, greenbelts, and fish and wildlife considered within this context.

There are storage sites on a number of rivers which could provide opportunities for water control and a more full utilization of the resource in meeting water supply needs and minimum streamflow requirements for anadromous and resident fish. Approximately 210,000 acre-feet of aggregate storage is required to provide 100 year protection in the basins. Storage could be provided at the Deming site on the main stem, Welcome, Rocky Ridge, Wurnich, Glacier and North Fork on the North Fork and Edfro on the South Fork. With storage there would be sufficient quantities of water to meet projected water supply needs even during a year of extreme low runoff without reducing streamflows below historical minimums during critical periods for fish. For further information on minimum streamflows for fish see the Area discussion on Fish and Wildlife.

Alternative objectives were considered in developing the Comprehensive Plan. The objectives represented both ends of the spectrum of interests, i.e., economic efficiency and environmental quality as discussed in the Puget Sound Area section of this Appendix. The alternative elements considered in plan formulation are described under Alternative Elements .

The single-purpose Appendices, V through XIV, provided a wide array of solutions. Necessary adjustments were made to these solutions in the formulation of a comprehensive plan for the Basins. These adjustments consisted of:

a. Water supply for the city of Bellingham would be obtained from storage from the multiple-purpose Edfro Dam on the South Fork of the Nooksack River in lieu of further diversions from the Middle Fork of the Nooksack River as recommended in Appendix VI. Further diversion from the Middle Fork would reduce low flows to a point which would be detrimental to fish life and the aesthetic values of the stream. In addition, the water quality of the South Fork is of a higher quality than that of the Middle Fork due to the lower silt content.

b. Fish and wildlife measures contained in Appendix XI were modified to a limited extent with additional artificial propagation facilities planned in lieu of several projects recommended for flood control and low flow augmentation.

SUMMARY OF PLAN

Early Action 1970-1980

The projected 1980 level of municipal and industrial water needs of the city of Bellingham and its service area could be satisfied through the construction of the Edfro Dam on the South Fork of the Nooksack River. Lynden would continue to obtain its water from surface sources while Ferndale, Blaine, Sumas, Emerson and other small communities would use ground water sources. Industrial water would also be developed from surface water sources.

An additional 20,000 acres of cropland would be placed under irrigation with water being supplied from both ground and surface sources. All of the development would be by individual farmers utilizing the most economical means available.

Compliance with Washington State water quality standards would be obtained through installation of adequate collection and treatment by the communities within the Basins. Pulp and paper mills would remove settleable solids from mill effluents prior to discharge, install adequate waste treatment facilities including outfalls and diffusers to achieve maximum dilution and dispersion and removal of existing sludge deposits in Whatcom Waterway to land disposal. A water quality surveillance program would be expanded in order to provide an adequate monitoring system with a sampling station on marine and fresh waters. A comprehensive sewerage plan would be developed for the Basins.

Navigation needs would be met through channel deeping of the Whatcom Waterway. Increased depth is required to accommodate bulk carriers and freighters. Lands found suitable for terminal or water transport-oriented industrial development would be retained for this purpose to insure future availability.

Wet moorage would be provided for pleasure boats through the construction of two small boat harbors with 1,766 moorage spaces.

Power needs for the Basin would be satisfied by the Northwest Regional system which is discussed under Power in the Area portion of this Appendix.

A multiple-purpose storage project on the South Fork of the Nooksack River would provide significant flood control for the Nooksack River flood plain. This project would provide 100-year protection to 15,000 acres downstream and a lesser degree of protection to an additional 34,000 acres of land. A levee project is programmed for construction during this period. Approximately 6,200 acres of agricultural land would receive 25-year protection. In connection with the Edfro project the protection would increase to 75 years. Flood plain management would provide an effective means of reducing future flood damages through land use zoning of lands in the flood plain consistent with the levels of flood protection provided. Floodproofing and warning systems also would be implemented.

Eight small watershed multiple-purpose projects are planned for implementation during this period to achieve floodwater damage reduction and improved water management. These projects consist of improved channels, dikes, small reservoirs and outlet control structures. Important complements to the watershed management projects are the programs of technical assistance and management and land treatment and drainage.

Campgrounds, picnic areas, beaches, and boat launching ramps would be developed on existing public lands, together with the acquisition of additional land and water areas to satisfy recreational needs. Recreation sites would be developed as part of the multiple-purpose Edfro storage project. Additional land and water areas would be acquired along the Puget Sound shoreline to provide badly needed marine parks. Over 40 recreation areas would be expanded or developed before 1980.

Land acquisition and fish and wildlife enhancement projects would be undertaken to increase the opportunities for this form of outdoor recreation. Additional fish hatcheries would be constructed for both resident and migratory fish together with rearing ponds and spawning channels. Low flow augmentation would be provided from the South Fork of the Nooksack multiple-purpose storage project. Important cross-sectional stream surveys would be undertaken during this period in order to determine the minimum and optimum streamflows required for fish production. Subsequent to these cross-sectional surveys further studies of new projects may be required, as well as reconsideration of the operation of existing projects.

Long-Range, 1980–2000.

Expansion of the transmission system from the Edfro Project to the distribution works would be necessary to satisfy the Bellingham service area water supply needs through the year 2020. The small and rural communities as well as industry would be supplied from combinations of ground and surface waters to the year 2020.

An additional 20,000 acres of land would be placed under irrigation during this period with water supplied primarily from the Nooksack RIver. The North fork multiple-purpose storage would assist in meeting peak irrigation demands.

Existing treatment and collection facilities would be expanded commensurate with the growth in population and industrial development to insure that the State water quality standards are continuallv met. The water quality program would be maintained.

Navigation needs during this period require that the Whatcom Waterway again be expanded to accommodate deep draft vessels. In addition, a new channel would be constructed in the Nooksack River delta to meet the expected increase in navigation in the area. Approximately 1,700 wet moorages would be provided through the Hale Passage small boat harbor project, proposed between 1980 and the year 2020. During this period all lands that were indicated in Appendix VIII, Navigation, as being suitable for terminal or water transport-oriented industrial development would be utilized for this purpose.

Power development would probably include pumped-storage at a number of the potential sites within the Basins. The North Fork multiple-purpose storage project would also assist in meeting the power demands. Oil or gas-fueled steam electric plants may also be located during this period to meet short-term peaking requirements. Development of nuclear electric generating plants may occur, but specific sites have not been determined and would be dependent upon future studies that consider shoreline characteristics, nearness to major load centers and impacts on the environment.

Flood control needs would be satisfied by the

North Fork multiple-purpose storage project and by levees in the lower valley. Levees would be constructed on the right bank between Lynden to above Everson and on the left bank opposite of Lynden. A ring dike to protect the community of Sumas is also programmed. These measures would provide 100-year protection to 3,000 acres and 25 to 50 year protection to an additional 7,000 acres of land. Flood plain management would also be continued. Implementation of land use zoning would preclude the necessity of further structural measures within the Basins.
the Basins.

Further programs and projects would be undertaken to satisfy watershed management needs. These would include 12 projects and a significant program of technical assistance, land treatment, and urban and rural water management.

Additional development of campgrounds, picnic areas, and other recreation facilities would be undertaken after 1980 at over 100 sites throughout the Basins, on public lands as well as on private lands, with both public and private sectors participating in the providing of recreation facilities. Recreation facilities provided at the North Fork project would be expanded commensurate with the growth in recreation use of the reservoir. Segments of the North, Middle and South Forks may be included in a State system of scenic and recreational rivers for retention in a free-flowing state for public use.

Additional fishing opportunities would be provided through anadromous and resident fishery enhancement measures. A number of fish passage improvements are planned during the long-range period as well as additional spawning habitat development. Wildlife preservation and enhancement programs begun prior to 1980 would be continued.

Table 3-19 summarizes the Nooksack-Sumas Basins elements of the Comprehensive Plan, showing the benefits and costs for the early action portion of the Plan, and provides a summary of investment costs by water resource functions for the entire 50-year period ending in 2020. The early action portion of the Plan includes programs amounting to $61,906,000 and projects costing $97,750,000, for a total investment of $159,656,000. Program and project investment costs for the 1980-2000 period amount to $214,388,000 and for the 2000-2020 period, $173,114,000, for a total 50-year investment of $547,158,000.

FEATURES OF THE COMPREHENSIVE PLAN

Municipal and Industrial Water Supply

The city of Bellingham is forecast to remain the largest supplier of water, both municipal and industrial, in the Nooksack-Sumas Basins. Future water needs of Bellingham are expected to be supplied by surface sources. By the year 2020, Bellingham is expected to deliver 53 percent of the Basins' potential demand of 293 mgd. Of the total municipal demand in the Basins, Bellingham would fulfill 73 percent and 51 percent of the total industrial demand in the year 2020. Lynden and Ferndale also would obtain their future waters from surface sources; while Blaine, Sumas, Everson and the other rural communities are expected to meet their future water requirements by utilizing ground water sources. The preponderance of self-supplied industrial water would be obtained from surface sources. The portion of the Comprehensive Plan dealing with municipal and industrial water supply is discussed by the following time periods:

1970-1980—The city of Bellingham must expand its water system in order to meet the anticipated demands of 1980. Bellingham has expanded its water system recently by 18 mgd giving it a total capacity of 78 mgd. An additional 40 mgd is required by 1980 to meet the projected demand for water. This additional water would be obtained from the South Fork of the Nooksack River. Water would be diverted from the South Fork into Mirror Lake which is currently utilized by Bellingham in its

TABLE 3-19. Comprehensive Plan, Nooksack-Sumas Basins

Feature	Item	1970–1980 Investment[1] Costs ($1000)	1970–1980 Average Annual Costs ($1000)	1970–1980 Average Annual Benefits Gross ($1000)	1970–1980 Average Annual Benefits Net ($1000)	1980-2000 Investment Costs ($1000)	2000–2020 Investment Costs ($1000)	1970–2020 Investment Costs ($1000)
Management Programs								
Water Quality Control	Monitoring, Evaluation, and Control Programs	840	--	--	--	710	790	2,340
Flood Control	Flood Plain Management	46	--	--	--	92	92	230
Watershed Management	Programs	60,532	--	--	--	70,389	65,373	196,294
Fish & Wildlife	Programs	488	--	--	--	430	435	1,353
Total Programs		$ 61,906				$ 71,621	$ 66,690	$200,217
Non-Storage Projects								
M&I Water Supply	Ground Water Use	1,663	192	192[4]	0	1,144	456	3,263
	Surface Water Use	7,112	1,073	1,073[4]	0	7,933	4,542	19,587
Irrigation Water Supply	Ground Water Use	2,230	311	311[4]	0	---	---	2,230
	Surface Water Use	470	35	35[4]	0	22,200	0	22,670
Water Quality Control	Sewerage Treatment & Collection Facilities	15,800	998	998[4]	0	19,030	37,080	71,910
Navigation	Channels	667	36	42	6	1,343	---	2,010
	Small Boat Harbors	(1,766)[3]	(105)[3]	(164)[3]	(59)	(1,108)	(2,326)	(5,200)
Power[2]								
Flood Control	Channels & Levees	2,500	125	141	16	10,000	--	12,500
Watershed Management	Flood water damage reduction, protection and rehabilitation, and water management	10,973	614	2,269	1,655	5,950	936	17,859
Recreation	Land Acquisition, Access & Recreation Facilities	25,680	1,743	3,156	1,413	27,100	49,800	102,580
Fish and Wildlife	Land Acquisition, Access & Enhancement Facilities	3,455	271	534	263	11,067	13,610	28,132
Total Non-Storage		$ 70,550	$ 5,398	$ 8,751	$ 3,353	$105,767	$106,424	$282,741
Storage Projects								
	Edfro							
M&I Water Supply		2,414	137	150	13	0	0	2,414
Flood Control		22,935	1,298	1,425	127	0	0	22,935
Recreation		1,609	92	100	8	0	0	1,609
Fish & Wildlife		242	13	15	2	0	0	242
Total Project		27,200	1,540	1,690	150	0	0	27,200
	North Fork							
Power		0	0	0	0	20,000	0	20,000
Flood Control		0	0	0	0	16,760	0	16,760
Recreation		0	0	0	0	100	0	100
Irrigation		0	0	0	0	40	0	40
Fish & Wildlife		0	0	0	0	100	0	100
Total Project		0	0	0	0	37,000	0	37,000
Total Storage		$27,200	$1,540	$1,690	$150	$37,000	0	$64,200
Total Program and Projects		$159,656	$6,938	$10,441	$3,503	$214,388	$173,114	$547,158

[1] Include cumulative annual program costs for the period for management featrues and capital costs for non-storage and storage projects.

[2] Power facilities not included in basin plan.

[3] General Navigation facilities cost and benefits for public small boat harbors only. Total pleasure boat facilities costs and benefits included with Recreation.

[4] Average annual benefits assumed equal to average annual costs.

distribution system. From Mirror Lake the water flows down Anderson Creek to Lake Whatcom and into Bellingham's distribution system at the Lake's outlet. Sufficient water can be made available from the Edfro project to meet the anticipated demands of 2020. Approximately 30,000 acre-feet of water is allocated for use by Bellingham. In addition to supplying the quantity of water required, the quality of the South Fork is superior to the Middle Fork as turbidity is much lower. Water supply is allocated $2,414,000 of the cost of the Edfro project which has an estimated total cost of $27,200,000.

Lynden and Ferndale are expected to satisfy their projected water needs by utilizing surface and ground water sources respectively. Blaine, Sumas, Everson and other small communities would utilize ground water sources to meet 1980 needs. Self-supplied industry in the basin would require an additional 20 mgd by 1980: the primary user being the aluminum industry located near Ferndale. Water for self-supplied industry would be diverted from the Nooksack River near Ferndale. The projected average daily water use for the Nooksack-Sumas Basins, planned supply and transmission investments and average annual costs are shown in the following tabulation for 1980.

Development	Needed by Year	1980 Average Daily Water Use mgd	Supply, Transmission Investment ($1000)	Average Annual Costs: Interests & Amort.[1]	Average Annual Costs: O&M[2]	Average Annual Costs: Total	Average Annual Benefits
Bellingham		118					
Development of diversion facilities from South Fork (Edfro Dam)	1975		8,000	374	656	1,030	1,030
Lynden		1					
Additional surface water development	1970 1975		161	8	4	12	12
Ferndale		1					
Additional surface water development	1975		82	4	5	9	9
Blaine, Sumas, Everson & Rural Communities		3					
Additional ground water development	1970		216	10	5	15	15
Self-Supplied Industry		32					
Additional surface & ground water development	1970		2,730	128	208	336	336
Total		155	$11,189	$524	$878	$1,402	$1,402

[1] Interest and amortization of capital investment costs.

[2] Total incremental increse in annual operation and maintenance cost including pumping and treatment costs.

[3] Average annual benefits assumed equal to average annual costs.

1980-2000—Bellingham's water needs in this period would be met by increased withdrawals from the Edfro project on the South Fork of the Nooksack River. Ferndale, Blaine, Sumas, Everson and other rural communities would continue to develop ground water sources to meet their projected demands. Lynden would continue to develop surface water sources to fulfill the needs for water during this period. Self-supplied industrial demand would about double during this time frame and would be met by further development of ground and surface water sources. Self-supplied industrial demand for water is expected to increase from 32 mgd in 1980 to 53 mgd in 2000. A summary of projected average daily use and investment costs for municipal and industrial water supply, required by the year 2000 is provided in the following tabulation:

Development	Needed by Year	2000 Average Daily Water Use mgd	Supply & Transmission and Treatment Investment ($1000)
Bellingham			
Additional development of South Fork Water	1990	149	6,703
Lynden			
Additional surface water development	1995	2	410
Ferndale			
Additional surface water development	1990	3	240
Blaine, Sumas, Everson & Rural Communities			
Additional ground water development	1995	3	84
Self-Supplied Industry			
Additional surface & ground water development	1990	53	1,640
Total		210	$9,077

2000-2020—Bellingham's water demand in this period would be satisfied by increased withdrawals from the South Fork storage project (Edfro Dam). Expansion of the transmission facilities would be required as will additional treatment facilities. Ferndale, Blaine, Sumas, Everson and other rural communities within the Basin would continue to develop ground water sources to meet their projected demands. Lynden would further utilize surface water sources to meet projected demands. Self-supplied industrial needs are expected to double again during this period, increasing to 122 mgd. This demand would be met by continued use of both ground and surface sources. A summary of projected average daily use and investment costs for municipal and industrial water supply, required by the year 2020, are provided in the following tabulation:

Development	Needed by Year	2020 Average Daily Water Use mgd	Supply Transmission and Treatment Investment ($1000)
Bellingham			
Additional development of South Fork water	2010	155	3,558
Lynden			
Additional surface water development	2015	4	984
Ferndale			
Additional surface water development	2005	6	396
Blaine, Sumas, Everson & Rural Communities			
Additional ground Water development	2010	6	60
Self-Supplied Industry			
Additional surface & ground water development		122	0
Total		293	$4,998

Irrigation

Approximately 38,000 acres of land are currently irrigated, with estimates that irrigated lands would increase to 58,000 acres by 1980 and to 78,000 acres by the year 2000. Of the 40,000 acres of additional land expected to be irrigated by the year 2000, 18,000 acres would be supplied from ground water sources and the remaining 22,000 acres from surface sources. Irrigation development as provided for in the Comprehensive Plan is discussed by the following periods:

1970-1980—Increased ground water use is planned and surface diversion with water pumped directly from adjacent rivers, as tabulated below:

1970-1980 New Irrigation		Diversion		Net Depletions	
Ground Water Supply (acres)	Surface Water Supply (acres)	Ground Water (acre-feet)	Surface Water (acre-feet)	Ground Water (acre-feet)	Surface Water (acre-feet)
18,000	2,000	34,000	4,000	23,000	3,000

Private investment cost for the new surface and ground water diversion is estimated at $135 per acre for a total investment cost of $2,700,000. Total annual charges, including interest and amortization and operation and maintenance costs of $220,000 are $346,000. The investment costs include provisions for on-farm sprinkler systems and pumping equipment.

1980-2000—During this period surface waters would be utilized through project-type developments

The areas appearing most feasible for project type development of surface waters are located around Lake Terrell, South of Tenmile Creek, and northeast of Lynden. The main stem of the Nooksack River is expected to be the source of water for those lands to be irrigated by surface sources. Acreage, diversion and net depletions are shown in the following tabulation:

1970-1980 New Irrigation		Diversion		Net Depletions	
Ground Water Supply (acres)	Surface Water Supply (acres)	Ground Water (acre-feet)	Surface Water (acre-feet)	Ground Water (acre-feet)	Surface Water (acre-feet)
0	20,000	0	38,000	0	26,000

Peak demands cannot be met by utilizing upstream storage without adversely affecting other water needs with the Basins. Accordingly, irrigation is allocated $40,000 of the North Fork project which has a total cost of $37,000,000. Total cost of irrigation during this period is $22,240,000 which is shared equally between private investment and the Federal Government.

2000-2020—Additional irrigation requirements are not anticipated during this period.

Water Quality Control

A large investment would be required to meet the present and future waste collection and treatment requirements in the Basins. Studies show that the minimum historical flows would adequately assimilate project residual waste loadings without deteriorating water quality. The water quality control elements of the Comprehensive Plan are:

1970-1980—The Comprehensive Plan calls for alleviation of adverse water quality conditions in Bellingham Harbor by construction of primary treatment facilities, and facilities which would remove 80 percent of the sulfite waste liquor from mill effluents; a submarine outfall with a diffuser and removal of existing sludge deposits in the Whatcom Waterway to land disposal.

The city of Ferndale, the area adjacent to Birch Bay and the food processing plants in Lynden would provide secondary treatment and disinfection facilities. Nooksack, Sumas and Everson require sewerage systems, secondary treatment and disinfection facilities. Bellingham would provide an adequate collection system, treatment of unintercepted waste discharge and a submarine outfall. Also septic tank effluent around Lake Whatcom would be intercepted and treated.

The investment costs of waste treatment and collection facilities called for by 1980 are estimated below. Program costs for water quality monitoring, evaluation and control are also included in the tabulation.

Water Quality Control
1970-1980

Feature	Investment Costs ($1000)	Average Annual Costs: Interest Amortization	O&M	Total	Benefits[2]
Monitoring, Evaluation and Control Program	840[1]				
Industrial Wastes					
Treatment	10,260	530	112	642	642
Municipal Wastes					
Treatment	1,010				
Sewers	3,030				
Subtotal	4,040	194	44	238	238
Recreation Waste					
Treatment	500	102	16	118	118
Total	$16,640	$826	$172	$ 998	$998

[1] Cumulative annual program costs for the period.
[2] Average annual benefits assumed at least equal to average annual costs.

Providing the 1980 flows recommended in Appendix XIII, Water Quality, for assimilation of residual waste loadings would not be a problem in the Nooksack River before 1980.

1980-2020–During this period, expansion by industry, new developments, and growth of urban and recreation areas require that new sewer interception systems be installed and treatment facilities be enlarged and/or constructed. Summarized in the following tabulation are estimated investment costs for water quality control for the periods 1980 to 2000 and 2000 to 2020.

Water Quality Control
1980-2020

Feature	Investment Costs ($1000) 1980-2020	2000-2020
Monitoring, Evaluation and Control Program	710[1]	790[1]
Industrial Wastes		
Treatment	6,950	9,000
Municipal Wastes		
Treatment	2,520	6,520
Sewers	7,560	19,560
Subtotal	10,080	26,080
Recreation Wastes		
Treatment	2,000	2,000
Total	$19,740	$37,870

[1] Cumulative annual program costs for the period.

Low flow augmentation may be necessary for assimilation of residual waste loadings by the year 2020. Flows required to meet water quality standards could be obtained from the proposed North Fork storage project. Flow releases from the reservoir could be programmed to meet the required flows in connection with anticipated water withdrawals during critical low flow periods. Detailed studies concerning this problem would be made prior to project construction.

Navigation

Navigation is projected to continue to be an important contribution to the economy of the Nooksack-Sumas Basins. The Port of Bellingham is expected to continue its program to develop new port terminal facilities that would serve its anticipated traffic base. Navigation development, as provided for in the Comprehensive Plan, is discussed by the following time periods.

1970-1980—Additional lands for water transport-oriented industries and deep draft terminals would be developed during this period. Lands in Bellingham Bay, near Blaine and in the vicinity of Ferndale are suitable for water-transport-oriented industry and terminal development (see Appendix VIII, Navigation).

Improvement of the Whatcom Creek Waterway at Bellingham would be required before 1980 to meet the increasing vessel drafts. A satisfactory means of disposing of dredged materials is assumed although problems are anticipated in finding suitable areas for this purpose. The planned navigation improvement is tabulated below:

Navigation Improvements
1970-1980

Channel	Channel Lengths (Miles)	Depth (Feet)	Channel Investment Cost ($1000)	Average Annual Costs: Interest & Amortization ($1000)	Average Annual Costs: Operation & Maintenance ($1000	Average Annual: Total ($1000)	Average Annual: Benefits ($1000)
Whatcom Waterway	1.5	40	$667	$31.2	$4.8	$36	$42

Expansion of the Bellingham and Blaine small boat harbors are planned for the period to meet the increase demand of recreation boating. These additions would provide an additional 870 wet moorages. The construction costs, average annual costs and benefits of the small boat harbor projects are shown in the following tabulation:

Small Boat Harbor Projects
1970-1980

Location	Wet Moorages	Investment Cost ($1000)	Average Annual[1] Costs ($1000)	Average Annual[1] Benefits ($1000)
Bellingham	430	873	52	81
Blaine	440	893	53	83
Total	870	$1,766	$105	$164

[1] General navigation facilities costs and benefits only, based on 50-year economic life amortized at a 4 5/8% interest rate. Total pleasure boat facilities costs and benefits included with Recreation.

1980-2000—During this period a navigation channel would be developed in the Nooksack Delta with further deepening of the Whatcom Waterway required. Super tankers and bulk cargo class vessels with drafts greater than 40-feet would be served by the Basin's terminal facilities. Improvements planned for implementation would fulfill the needs for the remainder of the study period. The improvements are tabulated below:

Navigation Improvements
1980-2000

Channel	Channel Dimension Length (Miles)	Depth (Feet)	Investments Cost ($1000)
Whatcom Waterway	1.8	46	481
Nooksack Delta	1.0	46	862
Total	2.8		$1,343

Pleasure boaters would require additional wet moorages within the Basins. A tentative small boat harbor project scheduled for construction prior to 2000 is tabulated below:

Small Boat Harbor Projects
1980-2000

Location	Wet Moorages	Investment Cost ($1000)
Hale Passage—East Side	550	$1,108

2000-2020—During this period further development of wet moorage spaces would be necessary with expansion of Hale Passage tabulated as follows:

Small Boat Harbor Projects
2000-2020

Location	Wet Moorages	Investment Cost ($1000)
Hale Passage—East Side	1,150	$2,326

Power

The electrical energy requirements of the Basins are satisfied on a regional basis with only a minor amount produced within the Basins. Puget Sound Power and Light Company operates the only power plant within the Basins. This plant, a hydroelectric project, is located at Nooksack Falls on the North Fork of the Nooksack River. Adequate power is forecast from existing sources to satisfy Area needs to about 1980. However, increased power generation would be necessary to meet the 2000 and 2020 needs.

Development of a multiple-purpose project, including hydroelectric power, on the North Fork above Nooksack Falls, is planned in the 1980-2000 period. Other purposes served by this project would be flood control, irrigation, recreation and fisheries. Preliminary studies indicate a hydroelectric plant installed at the project would have a total capacity of 26,200 kilowatts. Detailed engineering and economic studies are required to determine the exact features and operations of the project and benefits resulting from optimum use.

Base-load nuclear-electric generating plants are anticipated at a number of sites within the Puget Sound Area. One nuclear power plant, Cherry Point, is under consideration for power generation in the basin. Proposed development of any plant would require that adverse impacts on the environment be considered and the means provided to lessen these impacts when specific project studies are undertaken. For additional discussion of thermal-power generation, see the Puget Sound Area.

Flood Control

The elements of the Comprehensive Plan would reduce flood damages in the Nooksack-Sumas River Basins. Flood protection objectives would be met by the elements proposed in this Plan. These objectives have been defined in terms of flood frequency, with industrial and urban lands within the Basins recommended for a 100-year level of flood protection, agricultural lands at least 25-year level of protection, and lands in the flood plain to be used for parks, golf courses, and general recreation, requiring a level of flood protection of 10 to 15 years. A discussion follows by time periods of the portion of the Comprehensive Plan dealing with flood control:

1970-1980—A multiple-purpose storage project on the South Fork of the Nooksack River near Edfro Creek would be undertaken prior to 1980. This

project would provide 63,000 acre-feet flood control storage and in conjunction with levees during this period near Ferndale would provide 100-year protection for 15,000 acres of land, 25 to 50 year protection for 8,000 acres and 10 to 15 years protection for 26,000 acres.

Preliminary analysis indicates average annual flood control benefits attributed to the Sourth Fork Project are $1,425,000. Costs allocated to this function are estimated at $1,298,000 annually. The total multiple-purpose project cost is estimated at $27,200,000 with annual costs of $1,540,000. Other beneficial purposes of the project would be fishery enhancement, recreation and municipal and industrial water supply.

Construction of six miles of levees downstream of Ferndale on the right bank would protect 6,200 acres of agricultural land from floods having an occurence frequency of once in 25 years. This levee, designed for a flow of 47,000 cfs is estimated to cost $2,500,000. Average annual benefits are estimated at $141,000 versus costs of $125,000.

Flood plain management costs are estimated at $46,000 for this time frame. The tabulation below summaries the early action flood control programs and projects for the Nooksack-Sumas Basins:

Flood Control Element	Effective Flood Control Storage (Ac. Ft.)	River Mile	Height of Dam	Design Capacity (cfs)	Invest. Costs ($1000)	Average Annual[1] Costs Interest & Amort. ($1000)	Costs O&M ($1000)	Costs Total ($1000)	Benefits ($1000)
Flood Control Storage Project									
South Fork Nooksack River	63,000	15	170		22,935	1,072	226	1,298	1,425
Channel and Levee Construction									
Levee downstream of Ferndale				47,000	2,500	123	2	125	141
Subtotal					$25,435	$1,195	$228	$1,423	$1,566
Flood Plain Management					46			4	100
Total					$25,481	$1,195	$228	$1,427	$1,666

[1] Allocated flood control shown for storage projects.

1980-2000—During this period a multiple-purpose project would be constructed on the North Fork above Nooksack Falls, having a storage capacity of 21,000 acre-feet. Seven miles of levees would be constructed on the right bank from Lynden to above Everson and on 10 miles of the left bank opposite Lynden. A ring levee 3 miles in length would be constructed to protect Sumas. Coordination with Canada is required to accomplish the work at Sumas.

This combination of levees and upstream storage would provide 100-year protection to 3,000 acres and 25 to 50 year protection to 7,000 acres of land.

In addition to flood control, the North Fork project would provide power generation, low flow augmentation, fisheries, recreation opportunities and irrigation water supply. The total estimated cost of the project is $37,000,000 of which $16,760,000 would be allocated to flood control. The levee on the right bank between Lynden and Everson (7 miles) would be designed for a flow of 47,000 cfs and cost an estimated $3,500,000. Ten miles of levees opposite of Lynden would protect the area from flows up to 25,000 cfs and cost an estimated $5,000,000. A levee to protect the town of Sumas from floods occurring on a frequency of once in 100 years is estimated to cost $1,500,000.

Continuation of flood plain management in the Nooksack-Sumas Basins is programmed at an estimated cost of $112,000 for the twenty-year-period. Implementation of land use zoning will preclude the necessity of further structural measures within the Basins. In summary, 18,000 acres within the flood plain would receive 100-year protection, 15,000 acres 25 to 50-year protection, and 16,000 acres less than 25-year protection.

2000-2020—Flood plain management during this period would cost an estimated $112,000.

Watershed Management

The needs for watershed management in the Nooksack-Sumas Basins include floodwater damage reduction, rehabilitation protection of watershed

areas, and water management for a variety of purposes on rural and urban lands. The objectives of watershed management are to enable development of the resources of the Basins to achieve the highest level of production of food and fiber as would be economically justified, and to provide for development of urban areas not subject to floodwater hazards. The watershed management projects included in the Comprehensive Plan are viewed as complimentary to the existing and proposed major flood control projects also contained within the Plan. A continuing investment is required, both public and private, to insure protection of water and related land. This investment would be in the form of financial assistance, technical assistance, research, education and information. New installations, upgrading of existing facilities and improvements, or more intense application of land management practices would be required for flood protection, water management, and watershed rehabilitation and protection. While the acreage requiring treatment remains fairly constant by time periods, the intensity of treatment application and the composition of the combined measures varies with the inherent capability of the land as well as with the kind and intensity of use.

Federal and State land administrative agencies are responsible for the installation of these measures on land assigned to their management, while initiative of the individual property owner is required for installation of practices on lands in private ownership. Various Federal agencies and the State have programs of technical and financial assistance for individuals, local organizations, and subdivisions of government, including the Whatcom County Soil and Water Conservation District. The schedule of watershed management projects and programs provided for in the Comprehensive Plan is discussed by periods as follows:

1970-1980—Several projects are recommended for initiation prior to 1980 in order to reduce existing floodwater damage and provide water management for various purposes. Projects planned for early action are described briefly as follows:

Middle Nooksack Tributaries Watershed—Located on both sides of the main-stem between Deming and Lynden, this area contains 6,750 acres of land. Of this total 5,218 acres are cropland, 786 acres of forest, 550 acres of rural non-farm and urban, and 196 acres of miscellaneous other uses.

The work would consist of 7 miles of improved and stabilized channels, an outlet structure and 5 miles of dikes. These measures would provide flood water protection to 3,199 acres and improve drainage to 4,582 acres. These structural measures are estimated to cost $986,000 and would provide annual benefits of $131,000. The project's average annual costs including $9,000 for operation and maintenance is $55,000. In addition to these structural measures it would be possible for local interests to install effective land treatment measures for erosion control, flood management, drainage, and forest production management at an estimated cost of $1,245,000. Total cost of structural and non-structural measures amounts to $2,231,000.

Fishtrap—Bertrand Creeks Watershed—Located in both Canada and the United States, the watershed enters from Canada north of the city of Lynden. The project area within the United States contains 23,914 acres of which 18,501 acres are cropland, 3,237 are forest, 1,867 acres rural non-farm and urban, and 309 acres in miscellaneous use.

The work would consist of 37 miles of improved stabilized channel, two outlet structures and six miles of dikes. These measures would provide flood water protection to 13,159 acres and would improve drainage to 13,508 acres. These structural measures are estimated to cost $1,854,000, and will provide annual benefits of $436,000. The project's average annual cost including $17,000 for operation and maintenance is $104,000. In addition to the structural measures it would be possible for local interests to install land treatment measures for erosion control, flood management, drainage and forest production management at an estimated cost of $4,120,000. Total cost of structural and nonstructural measures amount to $5,974,000.

Sumas River Watershed.—Located in the northwest part of Whatcom County, this watershed drains to the north and is tributary to the Vedder River in Canada. The project contains 33,079 acres of land of which 18,287 acres are cropland, 12,650 acres are forest, 1,219 acres rural non-farm and urban, and 923 acres of miscellaneous usage.

The project would consist of approximately 22 miles of channel improvement, of which 10 miles would be on the Sumas River and its tributaries, 3 miles on Boone Creek and 9 miles on Johnson Creek and its tributaries. In addition, 1 debris basin would be installed on Swift Creek to control sediment resulting from an active landslide on Sumas Mountain. These structural measures are estimated to cost $1,241,000 resulting in average annual cost including

$10,000 for operation and maintenance of $68,000. This project would provide annual benefits of $462,000. In addition to these structural measures it would be possible for local interests to install land treatment measures for erosion control, flood management, drainage and forest production management at an estimated cost of $4,759,000. Total cost of the structural and non-structural measures amounts to $6,000,000.

Wiser Lake Watershed—Located between Bellingham and Lynden in northeast Whatcom County, this drainage area of 38,305 acres is mainly agricultural. Of the total acreage in the basin, 27,265 acres are cropland, 8,061 acres are forest, 1,577 acres rural nonfarm and urban, and 1,402 acres in miscellaneous uses.

The Wiser Lake watershed consists of four separate minor streams which require structural measures. The Scotch ditch in the northeast portion of the watershed requires 9 miles of improved channel and 1 outlet structure. Wiser Lake improvement consists of four miles of improved outlet to the Nooksack River and two pumping installations. An unnamed stream requires two miles of improved channel and an outlet structure. Ten-mile and Fourmile Creeks require 14 miles of improved channel and a reservoir for flood control storage and recreation. These structural measures are estimated to cost $2,448,000, and benefits which would accrue to these measures are estimated at $566,000 annually. Average annual costs of the project including $23,000 for operation and maintenance is $137,000. In addition to these structural measures, it would be possible for local interests to install land treatment measures for erosion control, flood management, and drainage and forest production management at an estimated cost of $5,800,000. Total cost of structural and non-structural measures amounts to $8,248,000.

Lower Nooksack Tributaries—Located in the area north and west of the Nooksack River in the vicinity of Ferndale, tributary to the Nooksack and the Red (or Lummi) Rivers, this area contains 19,835 acres of land of which 14,511 acres are cropland, 3,269 are forest, 1,668 acres rural nonfarm and urban, and 387 acres in miscellaneous uses.

The work would consist of 19 miles of improved stabilized flood control drainage channels, 5 outlet structures and 9 miles of dike. These measures would provide flood water protection to 10,499 acres and improve drainage to 12,559 acres. These structural measures are estimated to cost $2,370,000 and would provide annual benefits of $378,000. Average annual cost of the project including $24,000 for operation and maintenance is $135,000. In addition to these structural measures it would be possible for local interests to install land treatment measures for erosion control, flood management, drainage and forest production management at an estimated cost of $3,623,000. Total cost of structural and non-structural measures amounts to $5,993,000.

Dakota Creek Watershed—This is the first water course of any size south of the Canadian border and it discharges into Drayton Harbor. The watershed contains 20,314 acres of land, of which 8,270 acres are cropland, 9,706 acres are forest, 1,491 acres rural nonfarm and urban, and 847 acres in miscellaneous uses. The work, located mostly in the upper reaches of the watershed, would consist of 18 miles of channel improvement and stabilization. This measure would provide flood water protection to 593 acres and improve drainage to 3,118 acres. These structural measures are estimated to cost $430,000 and would provide annual benefits of $68,000. Average annual cost of the project including $3,000 for operation and maintenance is $23,000. In addition to these structural measures it would be possible for local interest to install land treatment measures for erosion control, flood damage, drainage, and forest production management at an estimated cost of $1,263,000. Total cost of structural and non-structural measures within the watershed amounts to $1,693,000.

California Creek Watershed—Located in the northwest portion of the Basin, California Creek flows northwest and has its outlet in Drayton Harbor at Blaine. The watershed includes 14,192 acres of which 8,384 acres are cropland, 4,118 acres are forest, 919 acres rural nonfarm and urban, and 771 acres in miscellaneous uses.

The work would consist of approximately 14 miles of channel improvement and stabilization and one reservoir for floodwater retention, recreation, and irrigation. These measures would provide floodwater protection to 1,397 acres and improve drainage to 3,500 acres. These structural measures are estimated to cost $471,000 resulting in an annual cost of $26,000 including $4,000 for operation and maintenance. The project would provide annual benefits of $88,000. In addition to these structural measures it would be possible for local interests to install land treatment measures for erosion control, flood prevention, water management, drainage and forest production management, at an estimated cost of

$1,249,000. Total cost of structural and nonstructural measures amounts to $1,720,000.

Silver (Marietta) Creek Watershed—Located about 10 miles northwest of Bellingham, the area is being developed for urban living. The area contains 10,866 acres, of which 5,704 acres are cropland, 3,479 acres are forest, 1,264 acres rural nonfarm and urban, and 419 acres in miscellaneous uses.

The work of improvement would consist of 16 miles of channel improvement, 5 miles of reconstructed dikes, and an outlet structure. These measures would provide floodwater protection to 2,736 acres and improve drainage to 4,999 acres. These structural measures are estimated to cost $1,173,000, and would provide annual benefits of $141,000. Average annual cost of the project, including $11,000 for operation and maintenance, is $66,000. In addition to these structural measures it would be possible for local interests to install land treatment measures for erosion control, flood prevention, water management, drainage and forest production management, at an estimated cost of $1,257,000. Total cost of structural management and non-structural measures amounts to $2,430,000.

Programs tabulated below include the complimentary features to the projects discussed above and other on-farm and urban on-site practices required in the Basin.

Watershed Management Practices 1970-1980

Program	Area (acres)	Cost ($1000)
Technical assistance		
and management	758,673	
Federal, regular		10,594
Federal, accelerated		501
Subtotal		$11,095
Installation of practices		
(non-Federal)		
State and corporate		8,456
Land treatment	472,305	10,961
Water management		
Agricultural	55,305	14,616
Urban	11,410	15,404
Subtotal		$49,437
Total		$60,532

1980-2000—The projects and programs scheduled for this period are tabulated below with estimated costs.

Watershed Management Practices 1980-2000

Program	Area (acres)	Cost ($1000)
Technical assistance		
and management	758,673	
Federal, regular		11,863
Federal, accelerated		501
Subtotal		$12,364
Installation of practices		
(non-Federal)		
State and corporate		11,276
Land treatment	472,305	14,614
Water management		
Agricultural	36,919	17,864
Urban	10,571	14,271
Subtotal		$58,025
Total		$70,389

Project	Area (acres)	Structural Measures Installation ($1000)
So. Fork Nooksack	122,178	600
Middle tributaries,		
Nooksack	56,095	1,400
Anderson Creek	8,789	300
Coastal Creek	16,702	550
Terrell Creek	9,503	1,900
Squalicum Creek	17,236	650
Lummi Island	11,744	550
Total	242,247	$ 5,950

Non-Federal costs include costs of on-going programs of development and treatment with redirection and acceleration to meet needs. Total costs are shown.

2000-2020 – The projects and programs recommended for implementation during this period are shown in the following tabulation:

Watershed Management Practices
2000-2020

Program	Area (acres)	Cost ($1000)
Technical assistance		
and management	758,673	
Federal, regular		10,708
Federal, accelerated		418
Subtotal		$11,126
Installation of practices		
(non-Federal)		
State and corporate		11,275
Land treatment	472,305	14,614
Water management		
Agricultural	35,000	12,720
Urban	11,584	15,638
Subtotal		$54,247
Total		$65,373

Project	Area (acres)	Structural Measures Installation ($1000)
N. Fork Nooksack	180,977	286
M. Fork Nooksack	62,845	100
Upper So. tributaries	109,231	100
Lake Whatcom	36,835	300
Chuckanut Mountain	22,352	150
Total	412,240	$ 936

Recreation

With the growing and increasingly mobile population in the metropolitan areas of Puget Sound Basin, the provision of sufficient facilities to satisfy outdoor recreation demand has become a serious problem. Recreation demand is increasing at a faster rate than supply. Although natural resources in the Nooksack-Sumas Basins are abundant, inadequate facilities and other constraints currently prevent proper utilization of the resource for recreation. A need exists for the preservation and public accessibility of the many natural attractions in the Nooksack-Sumas Basins, including the shoreline of Puget Sound, Lake Whatcom, Lake Terrell, and portions of the Nooksack River. The many miles of shoreline of the Nooksack River and its tributaries should be available to meet the public outdoor recreation needs. Comprehensive land use planning is required in order to guide urban development so that the environmental quality needs of the Basin's population are met.

In 1964 there were 75 publicly-administered outdoor recreation areas in the Basins – 23 administered by Federal agencies, 30 by the State, 22 by the county and city. Of the 357,130 acres classified as available for public visitation, 203,277 acres are in the Mt. Baker National forest, and 68,600 acres are in the North Cascades National Park. In addition to publicly administered areas, at least ten private operators offered facilities for public use in 1964. The existing supply of developed land is inadequate to satisfy present boating, camping and picnic demands. In addition to lands developed for boating facilities, an additional 602 rental moorage spaces were needed to satisfy the 1966 boating needs.

The broad recreation goal is to promote well-planned development and protection of existing resources, and to provide opportunities for the satisfaction of present and future outdoor recreation demand. Based on Federal ownership of land, plans and programs of recreation suppliers, expected population concentrations, as well as outdoor recreation needs, the assumption is made that Federal agencies would provide 20 percent of the required water-related opportunities, while the State, county and local agencies and private interests would supply 25, 35 and 20 percent, respectively. The recreation development, as provided for in the Comprehensive Plan, is intended to be compatible with the Washington State Outdoor Recreation and Open Space Plan. Additional facilities and acquisition and development of land and water areas are required in order to satisfy the above demand for water related outdoor recreation. These specific land and water area needs are stated in the following tabulation:

Recreation Land and Water Requirements
1960-2020

Activity	Unit	1960 Land	1960 Water	1980 Land	1980 Water	2000 Land	2000 Water	2020 Land	2020 Water
Swimming									
Beach	Acres	0	0	16	2	46	7	96	13
Pools	Sq. Ft.	51,200	25,600	113,200	56,000	232,200	116,600	446,200	222,600
Boating, Sailing, & Water Skiiing	Acres	25	0	75	0	175	0	345	0
Camping	Acres	144	--	494	0	1,094	--	2,294	--
Picnicking	Acres	145	--	315	--	615	--	1,115	--
Hiking	Miles	0	--	0	--	131	--	351	--

Source: Appendix X, Recreation.

The recreation development contained in the Comprehensive Plan for the Nooksack-Sumas Basin, is discussed by periods as follows:

1970-1980—Satisfaction of urgently needed marine-oriented recreation is called for by construction of small boat harbors on the shoreline as discussed under Navigation, with private investments in marina facilities also viewed as necessary to meet wet and dry moorage demands. Improvement and further development of recreation facilities at the 75 publicly administered outdoor recreation areas within the Basin, along with development of new areas on existing publicly administered land is recommended during this period. Access and improvement to State shorelines along the Nooksack River, including the North, Middle and South Forks, Lake Whatcom and numerous points on Puget Sound is called for, together with the designation of a network of scenic roads to provide travel links among recreational attractions, which would enhance driving for pleasure and sight-seeing opportunities within the Basin. Where practical, hiking and riding trails should also be developed within the corridor of scenic roads. Over 40 recreation sites are scheduled for improvement or development during this period.

Some of the potential recreation areas considered suitable for development in the Nooksack-Sumas Basins are shown in Appendix X, Recreation. These and other sites should be investigated for satisfying recreation needs. Investigation should be undertaken for development of safe public use easement over and adjacent to railroad tracks paralleling the shorelines of the Puget Sound. Scenic access easements should be be acquired along the rivers and streams throughout the Basins, to insure that greenbelts are provided within areas which are presently urbanized, and those destined for residential development. Preservation of the natural flood plain along the river as open space is recommended, consistent with a portion of the Comprehensive Plan discussed under Flood Control. To acquire new areas to fulfill the recreation needs, the feasibility of establishing international parks in the salt-water shoreline and in the Cascades should be explored.

A State system is suggested to retain important recreation rivers or river segments in a free-flowing state with the Nooksack River including the North, Middle, and South Forks recommended for further studies. Retention of outstanding natural areas and historical and archeological sites identified in Appendix X, Recreation, for the Nooksack-Sumas Basins would not conflict with other elements of the Comprehensive Plan and are included for inspirational and educational purposes and general public enjoyment. Investments for recreation facilities are tabulated below for the various water-related improvements:

Outdoor Recreation Improvements
1970-1980

Feature	Investment Costs ($1000)	Average Annual Costs: Interest & Amortization ($1000)	Average Annual Costs: Operation & Maintenance ($1000)	Average Annual Costs: Total ($1000)	Average Annual: Benefits ($1000)
Campgrounds	6,916				
Picnic areas	1,085				
Beaches	192				
Swimming pools	1,415				
Boating facilities	3,603				
Planning and design	3,304				
Land Acquisition	9,165				
Total	$ 25,680	$1,200	$543	$1,743	$ 3,156

1980-2000 –During this period, more extensive development of public lands is anticipated, although acquisition of private lands would be required to fulfill the demand. Need for all types of recreational development, including small boat basins, would continue during this period. Total recreation development costs during this period are estimated at $15,000,000 and costs for land acquisition estimated at $12,100,000, including buffer zones, with nearly 60 sites planned for expansion or new development.

2000-2020 –*After the year 2000 additional* development of public lands is planned, with some further acquisition of private lands expected. All types of recreational development, including small boat basins, would be required. Total recreation development costs during this period are estimated at $27,300,000 and $22,500,000 for land acquisition including buffer zones, with over 40 sites planned for expansion or new development.

Fish and Wildlife

The Nooksack-Sumas Basins offer numerous opportunities for projects and programs that, if implemented, would maintain and enhance wildlife populations, and increase fish and shellfish production. Portions of the Comprehensive Plan dealing with fish and wildlife are discussed by periods as follows:

1970-1980 –Important measures to fulfill fish needs planned for early action include the construction of a fish hatchery, a steelhead rearing pond, acquisition and development of access to 50 miles of stream, and acquisition and development of 20 access areas on salt water. Also provided in the early action program for fish enhancement is flood control and low flow augmentation on the South Fork of the Nooksack. These last two measures are provided through the construction of the Edfro project. Approximately 150 cfs have been tentatively selected for low flow augmentation to natural flows of this river during the low flow period, July through September. The exact amount of additional flow for fish use would be determined by detailed project studies. The amount of conservation storage to be allocated between municipal and industrial water supplies for the city of Bellingham and for fish use would be determined, in part by the benefits to be derived for each and by the willingness of sponsors to accept responsibility for payment of associated cost.

Important projects to propogate game populations include acquiring salt water access for waterfowl habitat, acquiring and developing 200 acres of band-tailed pigeon area, and adding to the existing game farm capacity to produce an additional 3,000 pheasants.

During this time frame, programs would be implemented which would benefit both hunters and fishermen. These programs include the development of new fish toxicants, fish disease control and lake fertilization techniques. Those programs associated with game animals include cooperative programs with private land owners to preserve habitat and insure hunter success, development of educational programs to stress renewable aspects and proper harvest of wildlife, and new methods for wildlife population

analysis, habitat improvement techniques, and compatible forest-wildlife practices. Project and program costs included in the Comprehensive Plan for fish and wildlife are tabulated as follows:

Fish and Wildlife
Projects and Programs
1970-1980

Projects

a. Acquisition and development of 12 lake access areas.

b. Enlargement of Barrett Lake.

c. Expand fish hatchery for game fish.

d. Fishing piers and habitat development at Lake Whatcom.

e. Acquisition and development of 50 miles of stream access.

f. Development of propagation sites for rearing anadromous game fish.

g. Construct steelhead rearing pond.

h. Acquisition and development of 20 salt water access areas.

i. Lake and stream improvement of Skookum Creek and Musto Marsh Ponds.

j. Acquire salt water access for waterfowl hunting.

k. Acquire and develop 1,900 acres of waterfowl habitat.

l. Acquire and develop 200 acres of band-tailed pigeon area.

m. Expand game farm to produce 3,000 pheasants.

n. Low flow augmentation and flood control—South Fork (Edfro Dam).

Programs

a. Develop fish disease control programs.

b. Develop new methods of lake and stream rehabilitation including fish toxicants.

c. Develop lake and stream fertilization techniques.

d. Development of cooperative programs with land owners to preserve wildlife habitat and assure access.

e. Development of education programs regarding value of wildlife.

f. Development of compatible forest-wildlife management techniques.

g. Perform cross-section studies of streams for optimum and minimum low flow determination.

h. Locate, survey, and mark boundaries of all State-owned second class tidelands in the Basin. Take steps to reserve all such lands to public use except as required for specific circumstances.

i. Perform an inventory of shellfish stocks and recreational use of tidelands.

Fish and Wildlife
Project and Program Costs[1]
1970-1980

Feature	Investment Costs ($1000)	Average Annual Costs: Interest & Amortization ($1000)	Average Annual Costs: Operation & Maintenance ($1000)	Average Annual Total ($1000)	Benefits ($1000)
Projects					
Non-Storage	3,455	162	109	271	534
Storage	242	11	2	13	15
Subtotal	$3,695	$173	$111	$284	$549
Programs	488[2]				365[3]
Total	$4,185				$914

[1] Includes allocated fishery enhancement costs from multiple-purpose storage projects.

[2] Cumulative program costs for the period.

[3] Some of program benefits included in with project benefits.

1980-2000–During this time period, projects are devoted to improve the habitat of migratory salmon. These projects include fish passage over major barriers in the Nooksack system, which would provide an additional 54 miles of stream habitat. Habitat improvement projects would be made on 14 streams, which would provide an additional 23 miles of fish habitat. One fish hatchery would be constructed during the period, as would a spawning channel one mile in length. Flood control would be provided on the North Fork of the Nooksack River. Programs initiated before 1980 would be continued in this period.

Project and program costs are summarized in the following tabulation:

Fish and Wildlife
Projects and Programs[1]
1980-2000

Feature	Investment Costs ($1000)
Projects	11,167
Programs	430[2]
Total	$11,597

[1] Includes allocated fishery enhancement costs from multiple-purpose storage projects.

[2] Cumulative program costs for the period.

2000-2020 –After the year 2000 three hatcheries would be constructed and 100 acres of rearing facilities would be provided for migratory salmon. Programs initiated earlier to improve fish and game would be continued.

Project and program costs are summarized in the following tabulation:

Fish and Wildlife
Projects and Programs
2000-2020

Feature	Investment Cost ($1000)
Projects, nonstructural	13,610
Programs	435[1]
Total	$14,045

[1] Cumulative program costs for the period.

COST–BENEFIT SUMMARY

The investment costs by feature are shown in Tables 3-20 and 3-21 for the Nooksack-Sumas Basins with the costs distributed between Federal, State, local and private interests. Average annual costs and benefits also are shown for projects recommended for implementation prior to 1980. The investment costs include cumulative annual program costs for each of the three planning periods as shown in Table 3-20 and capital project costs as shown in Table 3-21. Interest and amortization costs are based on a 100-year economic life with appropriate allowances made for major replacements. An interest rate of 4-5/8 percent was used in the economic analysis. All measures proposed for early action are justified on the basis of tangible benefits. Benefits for M&I water supply and water quality improvement were assumed equal to all charges.

Investment costs were allocated to the various features on the basis of available information including the technical appendices, multipurpose project studies, and experience at similar projects.

TABLE 3-20. Program investment costs,[1] Nooksack-Sumas Basins ($1000).

Feature	Private	Government: Local	Government: State	Government: Federal	Total
			1970–1980		
Water Quality Control	140	140	373	187	840
Flood Control		32	9	5	46
Watershed Management	41,455	4,410	3,721	10,946	60,532
Fish and Wildlife			488		488
Subtotal	$41,595	$4,582	$4,591	$11,138	$61,906
			1980–2000		
Water Quality Control	171	171	264	104	710
Flood Control		65	18	9	92
Watershed Management	47,794	5,351	4,961	12,283	70,389
Fish and Wildlife			430		430
Subtotal	$47,965	$5,587	$5,673	$12,396	$71,621
			2000–2020		
Water Quality Control	187	187	298	118	790
Flood Control		65	18	9	92
Watershed Management	41,761	7,538	4,961	11,113	65,373
Fish and Wildlife			435		435
Subtotal	$41,948	$7,790	$5,712	$11,240	$66,690
Total	$131,508	$17,959	$15,976	$34,774	$200,217

[1] Cumulative annual program costs over the period.

TABLE 3-21. Project investment costs[1] and cost-benefit summary, Nooksack-Sumas Basins ($1000)

Feature	Investment Costs					Annual Costs			Annual Benefits	
		Government				Interest &	Operation &			
	Private	Local	State	Federal	Total	Amortization[2]	Maintenance	Total	Total	Net
				To 1980						
M&I Water Supply	2,730	8,459	0	0	11,189	524	878	1,401	1,415	13
Irrigation	2,700	0	0	0	2,700	126	220	346	346	0
Water Quality Control	10,260	2,020	1,010	2,510	15,800	826	172	998	998	0
Navigation[3]	0	210	0	457	667	31	5	36	42	6
Flood Control	0	250	0	25,185	25,435	1,195	228	1,423	1,566	143
Watershed Mgmt.[4]	0	3,292	0	7,681	10,973	514	100	614	2,269	1,655
Recreation	5,458	9,551	6,822	5,458	27,289	1,275	3,560	1,835	3,256	1,421
Fish & Wildlife	0	0	3,455	242	3,697	173	111	284	549	265
Sub-Total	$21,148	$23,782	$11,287	$41,533	$97,750	$4,664	$2,274	$6,938	$10,441	$3,503
				1980–2000						
M&I Water Supply	1,640	7,437	0	0	9,077					
Irrigation	11,120	0	0	11,120	22,240					
Water Quality Control	6,950	5,040	2,520	4,520	19,030					
Navigation[3]	0	448	0	895	1,343					
Power	0	0	0	20,000	20,000					
Flood Control	0	1,000	0	25,760	26,760					
Watershed Mgmt.[4]	0	1,785	0	4,165	5,950					
Recreation	5,440	9,520	6,800	5,440	27,200					
Fish & Wildlife	0	0	11,067	100	11,167					
Sub-Total	$25,150	$25,230	$20,387	$72,000	$142,767					
				2000–2020						
M&I Water Supply	0	4,998	0	0	4,998					
Irrigation	0	0	0	0	0					
Water Quality Control	9,000	13,040	6,520	8,520	37,080					
Navigation[3]	0	0	0	0	0					
Flood Control	0	0	0	0	0					
Watershed Mgmt.[4]	0	281	0	655	936					
Recreation	9.960	17,430	12,450	9,960	49,800					
Fish & Wildlife	0	0	13,610	0	13,610					
Sub-Total	$18,960	$35,749	$32,580	$19,135	$106,424					
Total	$65,258	$84,761	$64,254	$132,668	$346,941					

1 Capital project costs.
2 Of initial investment and major replacement.
3 Costs and benefits for pleasure boating moorage facilities included with Recreation.
4 Installation of structural measures only.

SEQUENCE OF DEVELOPMENT

The projects and programs of the Comprehensive Plan are summarized in Table 3-22 by period. The project numbers identify features on Figure 3-3.

TABLE 3-22. Future projects and programs, Nooksack-Sumas Basins

Projects Prior to 1980

Project No.

Municipal and Industrial Water Supply

1. Expansion of existing water supply and transmission systems at Ferndale, Lynden, Sumas, Blaine and other rural communities.

2.* Increase capacity of self-supplied industrial surface water system.

3. Provide water supply storage from Edfro multiple-purpose project, South Fork Nooksack River and transmission system—Bellingham.

Irrigation

4.* Installation of individual farm irrigation pumping and sprinkler systems (private).

Water Quality Control

5. Construction of secondary treatment and disinfection facilities at Ferndale, Lynden food processing plants and Birch Bay area.

6. Construction of secondary treatment, disinfection, and sewage interception facilities at Everson, Nooksack and Sumas.

7. Installation of interception facilities for septic tank effluent at Lake Whatcom.

8.* Improvement of collection and treatment of waste discharges and submarine outfall at Bellingham.

9. Improvement of collection and treatment of waste discharges and submarine outfall at Bellingham.

Navigation

10. Small boat harbor development at Bellingham and Blaine.

11. Channel improvement at Bellingham.

Flood Control

3. Construction of flood control storage at Edfro multiple-purpose project—South Fork Nooksack River.

12. Construction of levee—Ferndale.

Watershed Management

13. Small watershed multiple-purpose project—Middle Nooksack tributaries.

14. Small watershed multiple-purpose project—Fishtrap and Bertrand Creeks.

15. Small watershed multiple-purpose project—Lower Nooksack tributaries.

16. Small watershed multiple-purpose project—Sumas River.

17. Small watershed multiple-purpose project—Dakota Creek.

18. Small watershed multiple-purpose project—California Creek.

19. Small watershed multiple-purpose project—Silver (Marietta) Creek.

20. Small watershed multiple-purpose project—Wiser Lake.

Recreation

21. Development of one recreation site at Point Roberts.

22. Development of two recreation sites along saltwater shoreline from Birch Bay to Blaine.

23. Development of one recreation site along saltwater shoreline from Lummi Bay to Birch Bay.

24. Development of one recreation site in this vicinity.

25. Development of two recreation sites along the saltwater shoreline of Lummi Island and Hale Passage.

26. Development of two recreation sites along the saltwater shoreline of Bellingham Bay and south.

27. Development of two recreation sites in this vicinity.

28. Development of two recreation sites along Nooksack River from Lynden to junction with South Fork of Nooksack.

29. Development of two recreation sites along Nooksack River from junction with South fork to National Forest.

30. Development of two recreation sites along Middle Fork Nooksack River to National Forest.

31. Development of three recreation sites along South Fork Nooksack River to National Forest.

32. Development of 15 recreation sites in National Forest and Nation Park.

3. Installation of recreation facilities at Edfro multiple-purpose project—South Fork Nooksack River.

Fish and Wildlife

33.* Acquisition and development of 12 lake access area.

34. Enlargement of Barrett Lake.

35.* Expansion of fish hatchery for game fish.

36. Development of fishing piers and habitat at Lake Whatcom.

37.* Acquisition and development of 50 miles of stream access.

38.* Acquisition and development of 20 salt water access areas.

39.* Acquisition and development of 1,900 acres of waterfowl habitat.

40.* Acquisition and development of 200 acres of band-tailed pigeon area.

41.* Acquisition of salt water access area for waterfowl hunting.

*Projects not shown on Figure 3-3.

TABLE 3-22. Future projects and programs, Nooksack-Sumas Basins (Cont'd)

42.* Development of propagation sites for rearing anadromous game fish.

43.* Construction of steelhead rearing pond.

44.* Expansion of game farm to produce 3,000 pheasants annually.

45. Improvement of lake and stream on Skookum Creek and Musto Marsh Ponds.

3. Low flow augmentation from Edfro multiple-purpose project—South Fork Nooksack River.

Programs Prior to 1980

Water Quality Control

a. Establish and operate water quality surveillance stations at key salt and fresh water locations and prepare comprehensive sewerage plan for the Basins.

Flood Control

b. Establish and administer county-wide flood plain zoning measures under flood plain management program.

Watershed Management

c. Provide technical assistance and management for State and Federal lands.

d. Provide technical assistance for onfarm and other private practices.

Fish and Wildlife

e. Develop lake fertilization techniques.

f. Make wildlife population analysis and timberland management practices studies, develop habitat improvement techniques and an education program on proper game hunting concepts, and begin a program with land owners for game habitat retention and hunter access.

g. Develop fish disease controls and new toxicants.

h. Conduct cross-sectional stream surveys to determine minimum and optimum streamflows for fish.

i. Locate, survey, and mark boundaries of all State-owned second class tidelands in the Basin. Take steps to reserve all such lands for public use except as required for specific circumstances.

j. Perform an inventory of shellfish stocks and recreational use of tidelands.

Projects 1980–2000

Municipal and Industrial Water Supply

46. Expansion of existing surface water supply and transmission facilities—Bellingham.

47. Expansion of existing water supply and transmission systems at Ferndale, Sumas, Blaine, Lynden and other rural communities.

48.* Additional development of self-supplied industrial surface water system.

Irrigation

49. Provide irrigation water supply to serve cropland at Lake Terrell and northeast of Lynden from North Fork multiple-purpose project—North Fork Nooksack River.

Water Quality Control

50.* Expansion of waste treatment and interception facilities for municipalities, industry and recreation.

Navigation

51. Small boat harbor development—Hale Passage, East Side.

52. Channel improvement at Bellingham.

53. Navigation channel dredging in Nooksack River delta.

Power

49. Installation of hydroelectric facilities at North Fork multiple-purpose project—North Fork Nooksack River.

Flood Control

49. Flood control storage at North Fork multiple-purpose project—North Fork Nooksack River.

54. Construction of levee on the left bank (10 miles)—opposite Lynden.

55. Construction of levee to protect Sumas.

56. Construction of levee between Lynden and Everson.

Watershed Management

57. Small watershed multiple-purpose project—South Fork Nooksack.

58.* Small watershed multiple-purpose project—Middle tributaries Nooksack.

59. Small watershed multiple-purpose project—Anderson Creek.

60.* Small watershed multiple-purpose project—Coastal Creeks.

61. Small watershed multiple-purpose project—Terrell Creek.

62. Small watershed multiple-purpose project—Squalicum Creek.

63. Small watershed multiple-purpose project—Lummi Island.

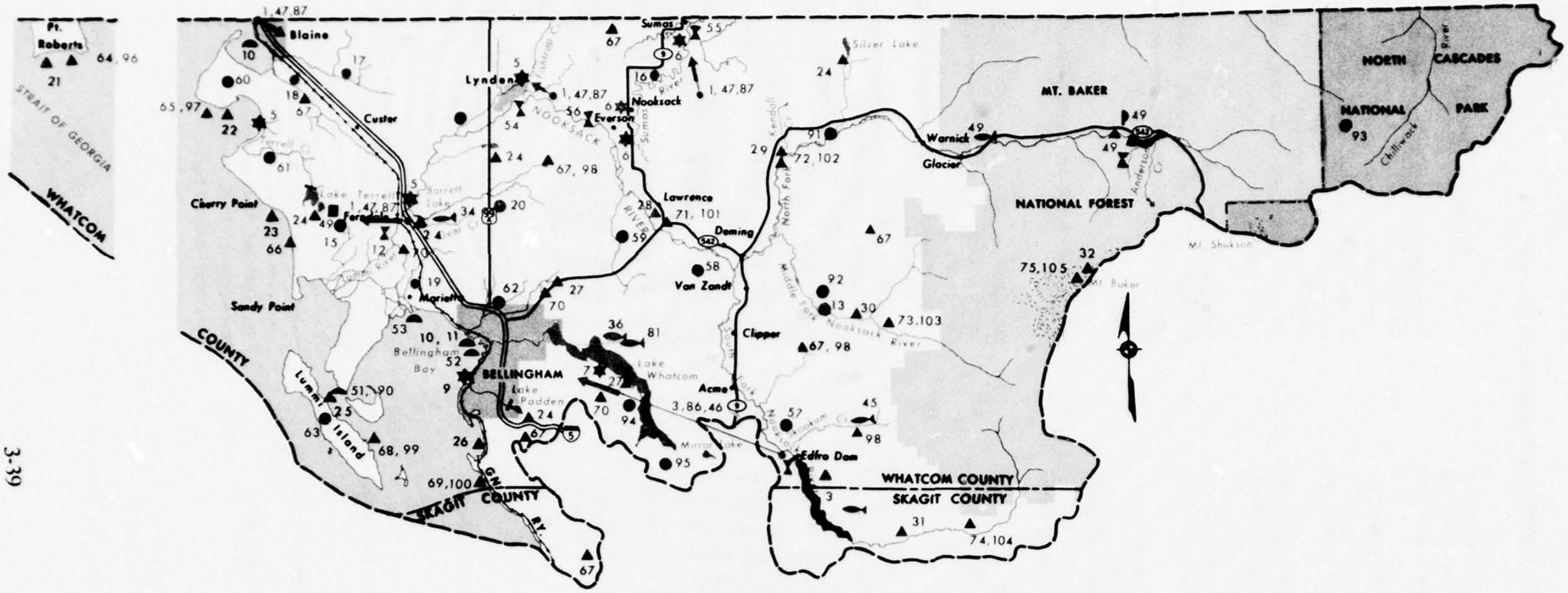
Recreation

64. Development of one recreation site at Point Roberts.

65. Development of three recreation sites along saltwater shoreline from Birch Bay to Blaine.

66. Development of two recreation sites along saltwater shoreline from Lummi Bay to Birch Bay.

*Projects not shown on Figure 3-3.



LEGEND

Proposed early-action projects	FEATURE	Proposed long-range projects
	M & I Water Supply	
	Irrigation	
	Water Quality Control	
	Navigation	
	Power	
	Flood Control	
	Watershed Management	
	Recreation	
	Fish & Wildlife	
	Dams & Reservoir	

Scale in Miles

5 0 5 10

NOOKSACK-SUMAS BASINS

FIGURE 3-3. Comprehensive Plan elements

ITEMS NOT SHOWN ON MAP

Rural and small community water supply projects

Irrigable land and private irrigation developments ●

Terminal and water-transport oriented industrial lands ●

Small watershed boundaries ●

Scenic highway and potential recreation river segments

Fish and wildlife projects yet to be sited

● See functional appendix for location maps

TABLE 3-22. Future projects and programs, Nooksack-Sumas Basins (Cont'd)

67. Development of one recreation site in this vicinity.
68. Development of two recreation sites along the saltwater shoreline of Lummi Island and Hale Passage.
69. Development of three recreation sites along the saltwater shoreline of Bellingham Bay and south.
70. Development of two recreation sites in this vicinity.
71. Development of three recreation sites along Nooksack River from Lynden to junction with South Fork of Nooksack.
72. Development of three recreation sites along Nooksack River from junction with South Fork to National Forest.
73. Development of two recreation sites along Middle Fork Nooksack River to National Forest.
74. Development of four recreation sites along South Fork Nooksack River to National Forest.
75. Development of 20 recreation sites in National Forest and Nation Park.
49. Installation of recreation facilities at North Fork multiple-purpose storage project—North Fork Nooksack River.

Fish and Wildlife

76.* Construction of fish passage facilities.
77.* Improvement of salmon habitat on 14 streams.
78.* Construction of one salmon hatchery.
79.* Construction of one mile of spawning channel for salmon.
49. Low flow augmentation from North Fork multiple-purpose project—North Fork Nooksack River.
80.* Construction of fish hatcheries for game fish.
81.* Construction of fishing piers on Lake Whatcom.
82.* Continue acquisition of wildlife areas.
83.* Development of access and parking to all State-owned beaches.
84.* Development of one subtidal park for skin divers.
85.* Acquisition of five miles of tideland for public use.

Programs 1980–2000

Water Quality Control

k. Continuation of water quality monitoring, evaluation and control programs.

Flood Control

l. Continuation of flood plain management programs.

Watershed Management

m. Provide technical assistance and management for State and Federal lands.
n. Provide technical assistance for onfarm and other private practices.

Fish and Wildlife

o. Continuation of fish and wildlife programs.
p. Improvement of public beaches for clam culture.

Projects 2000–2020

Municipal and Industrial Water Supply

86. Expansion of existing surface water supply and transmission facilities—Bellingham.
Expansion of existing water supply and transmission systems at Ferndale, Sumas, Blaine, Lynden and other rural communities.
88.* Additional development of self-supplied industrial surface water system.

Water Quality Control

89.* Expansion of waste treatment and interception facilities for municipalities, industry and recreation.

Navigation

90. Small boat harbor expansion—Hale Passage—East Side.

Watershed Management

91. Small watershed multiple-purpose project—North Fork Nooksack.
92. Small watershed multiple-purpose project—Middle Fork Noolssck.
93.* Small watershed multiple-purpose project—Upper South tributaries of Chilliwack.
94. Small watershed multiple-purpose project—Lake Whatcom.
95. Small watershed multiple-purpose project—Chuckanut Mountain.

Recreation

96. Development of one recreation site at Point Roberts.
97. Development of two recreation sites along saltwater shoreline
98. Development of one recreation site in this vicinity.
99. Development of one recreation site along the saltwater shoreline of Lummi Island and Hale Passage.
100. Development of one recreation site along the saltwater shoreline of Bellingham Bay and south.
101. Development of four recreation sites along Nooksack River from Lynden to junction with South Fork of Nooksack.
102. Development of five recreation sites along Nooksack River from junction with Sourth Fork to National Forest.
103. Development of three recreation sites along Middle Fork Nooksack River to National Forest.
104. Development of six recreation sites along South Fork Nooksack River to National Forest.
105. Development of 20 recreation sites in National Forest and National Park.

*Projects not shown on Figure 3-3.

TABLE 3-22. Future projects and programs, Nooksack-Sumas Basins (Cont'd)

	Fish and Wildlife
106.*	Construction of three new salmon hatcheries and development of 100 acres of rearing facilities.
	Programs 2000–2020
	Water Quality Control
q.	Continuation of water quality monitoring, evaluation and control programs.
	Flood Control
r.	Continuation of flood plain management programs.
	Watershed Management
s.	Provide technical assistance and management for State and Federal lands.
t.	Provide technical assistance for on-farm and other private practices.
	Fish and Wildlife
u.	Continuation of fish and wildlife programs.

*Projects not shown on Figure 3-3.

PLAN ACCOMPLISHMENTS

The accomplishments of the Comprehensive Plan are shown in Table 3-23. All of the quantifiable needs of the Basins would eventually be met by the Plan, except flood control. Residual damage would remain due to the degree of protection provided on agricultural lands within the Basins.

Urban water management needs would be entirely met by the year 2020. In the preceding time periods, a residual is shown as intensive land use would be required to achieve a minimum density in order to facilitate project undertaking.

Recreation needs are assumed to be satisfied by including all the projects and programs called for in Appendix X, Recreation, for the Nooksack-Sumas Basins and construction of the Edfro and North Fork multiple-purpose projects with public recreation sites and facilities.

The sport and commercial fishery needs are assumed to be met by programs and projects contained in the Plan, as the future consumptive withdrawals for municipal and industrial water supply and irrigation would not reduce the minimum flows during the critical summer season less than those that have historically occurred. Future municipal and industrial water supply withdrawals are generally planned for accomplishment by drawing water from storage during the summer season with a minimum flow to remain in the stream below the point of diversion. Where a diversion is planned, the projects would be carried out in accordance with existing agreements with the Washington Departments of Fisheries and Game. Upon completion of detailed river studies to determine the required minimum and optimum flows for fish production, as called for during the early action period, adjustments may be made in the Plan. These adjustments could involve additional impoundments on and adjustment to the operations of existing projects. During the critical summer season the streamflows immediately below the planned storage projects would be at least equal to the historical lows. In most cases, higher than historical minimum flows are provided as justified by fishery enhancement benefits.

The sport and commercial fishery needs would be satisfied by the Plan assuming that present pollution problems are corrected. As only specific solutions for early action were provided for wildlife needs, subsequent periods were assumed to be satisfied by projects and programs that would be developed later. A reduction in hunter success is anticipated with a willingness of hunters to accept a lower success ratio, necessary in order to meet projected needs. Hunters also may be required to hunting areas in Eastern Washington.

TABLE 3-23. Comprehensive Plan accomplishments, Nooksack-Sumas Basins

Feature	Units	To 1980			To 2000			To 2020		
		Needs	Accomp.	Residual	Needs	Accomp.	Residual	Needs	Accomp.	Residual
M&I Water Supply	MGD	83	83	0	139	139	0	220	220	0
Irrigation	1000 Acre-Feet	38	38	0	76	76	0	76	76	0
Water Quality Control										
Waste	1000 Pop. Equiv.	2,981	2,981	0	3,503	3,503	0	3,966	3,966	0
Flow[1]	cfs	180	180	0	350	350	0	725	725	0
Navigation										
Commercial	1000 Short Tons	3,200	3,200	0	11,500	11,500	0	27,900	27,900	0
Pleasure Boats	Wet Moorages	780	870	(90)	1,410	1,420	(10)	2,490	2,570	(80)
Power[2]										
Flood Control	$1000	1,210	909	301	1,970	1,710	260	3,350	2,945	405
Watershed Management										
Flood Prevention	1000 Acres	*113.0*	113.0	*0*	*113.0*	*113.0*	*0*	*113.0*	*113.0*	*0*
Watershed Protection & Rehabilitation[4]	1000 Acres	792.2	792.2	0	792.2	792.2	0	792.2	792.2	0
Water Management[3]										
Agricultural	1000 Acres	55.4	55.4	0	92.3	92.3	0	123.1	123.1	0
Urban	1000 Acres	33.6	11.4	22.2	33.6	22.0	11.6	33.6	33.6	0
Recreation	1000 User-days	2,600	2,600	0	6,300	6,300	0	12,900	12,900	0
Fish and Wildlife										
Sport										
Fishing	1000 User-days	170	170	0	425	425	0	835	835	0
Hunting	1000 User-days	69	69	0	159	159	0	213	213	0
Commercial Fishing	1000 Pounds	115	115	0	2,610	2,610	0	4,278	4,278	0

1 *Nooksack River at Ferndale.*

2 Power needs were projected for the Puget Sound Area only.

3 Needs and accomplishments are cumulative.

4 The necessary level of management is assumed to be established throughout the Basins, otherwise some residual could result.

ALTERNATIVE ELEMENTS

Alternative measures considered to those elements contained in the Comprehensive Plan and reasons for not adopting these alternatives are discussed in this section.

Alternatives to Storage Project on South Fork (Edfro)

A number of alternatives to upstream flood control storage at the Edfro project were investigated, including levee and channel improvements. These measures were not found to be economically feasible due to extensive work required to provide protection from unregulated flows. Flood plain evacuation was not found to be economically feasible because of the magnitude of existing improvements and the facilities that would require relocation. Flood proofing of existing buildings also was evaluated as an alternative for reducing present and future flood damages. About 25 percent of the estimated $853,000 average annual flood damages of about $210,000 occurs to buildings. The majority of these buildings are of wood frame construction and flood proofing would require structural treatment that would not be economically feasible. This alternative would not meet the present or future needs for optimum development and utilization of the Nooksack-Sumas flood plain. Diversion of the flood waters to the Lummi River was investigated and determined to be economically infeasible because of extensive transportation system relocation costs. Alternative storage sites were investigated in the Basins. However, the Edfro site is considered to be the most economical site for storage development. Low flow augmentation for fish and future water supply for Bellingham can be met by the project.

Alternatives to North Fork Storage Project

The alternatives to this project for flood control measures is essentially the same as for the Edfro project. Power needs in the future require that all economically feasible projects be considered for development. Accordingly, no alternatives are available to the North Fork project which would not meet the future needs for optimum development of the Basins. Irrigation needs can be met only by storage as all feasible ground water supplies would be developed.

Alternatives to Levees

Levees are required to complement storage at both the Edfro and the North Fork projects in order to achieve the desired flood protection objectives. There are no feasible storage sites that could be in the Basins which would provide an equivalent protection at less cost than the levees. The levees can be constructed commensurate with the development occurring in the flood plain.

Alternatives to Edfro Storage Project for Municipal and Industrial Water Supply

Alternatives considered for meeting Bellingham's future water supply needs included desalinization and pumping of ground water.

Costs associated with desalinization are decreasing with improved technology but in most instances use of desalinization facilities are economically feasible only in situations where the nearest potable water supply is a considerable distance away. The Key West Desalting Plant (2.62 mgd) operating at Key West, Florida, might be used for determination of cost estimates. This plant utilizes the multiple-stage flash evaporation process to deliver desalted water at approximately $.85 per thousand gallons with fuel oil as a source of energy. The U.S. Atomic Energy Commission predicts costs as low as $.19 per thousand gallons for the integrated nuclear power desalting plants by 1980. Costs of this order will be realized only in the extremely large plants producing 500 to 800 mgd. These costs are much higher than the cost of water from Edfro storage including transmission and treatment facilities investments.

The ground water resources in the Nooksack-Sumas Basins have been estimated to be replenished at a rate of about 50,000 acre-feet annually, approximately 45,000 gallons per day. This resource is not considered adequate to meet the average daily needs of a large water purveyor like the city of Bellingham.

Consideration was also given to satisfying the water needs of Bellingham by increased withdrawals from the Middle Fork of the Nooksack River, utilizing the North Fork of the Nooksack River and by utilizing waters from the main stream. Utilization of the North and Middle Forks would require the construction of storage projects to furnish the necessary quantities of water needed. Thirty-day low flows

in both streams, under existing conditions, approximate 95 to 130 cfs which is the minimum considered necessary to maintain fish life and the aesthetic qualities of the stream. Single-purpose storage projects to satisfy municipal and industrial water supply needs for Bellingham, together with necessary transmission facilities, would be in excess of the recommended plan cost for water supply. Direct pumping and treatment of water from the Nooksack River also is estimated to cost more than the alternative selected. The main stream diversion would require extensive treatment to meet acceptable standards. Consideration was given to further drafting of Lake Whatcom. Even if use of this source was not constrained by an existing court order, further drawdown would be harmful to recreation and aesthetic values of the lakes.

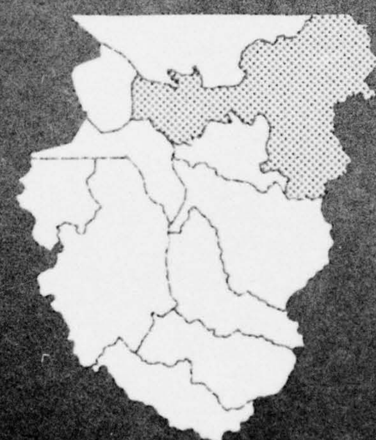
Alternatives to Recreation and Fish and Wildlife Measures

As limited information was provided with regard to specific locations of recreation developments, no analysis could be made to determine if sites and proposed developments selected were necessarily the most economical that could be provided to achieve a given amount of recreation benefits. All fish and wildlife measures recommended in Appendix XI, Fish and Wildlife, were found to be compatible with the Comprehensive Plan at least those projects and programs recommended for implementation prior to 1980. As insufficient information was available in terms of alternatives for satisfying fish and wildlife needs, those alternatives presented in Appendix XI, Fish and Wildlife, were adopted and included in the Comprehensive Plan with the exception of recommendations for flood control and low flow augmentation on the main-stem and tributaries of the Middle Fork of the Nooksack River recommended for action between 1980 and 2000.

As no flows were specified in Appendix XI, Fish and Wildlife, for low flow augmentation or the level of flood control required in order to obtain a given level of fish benefits, storage projects on the main-stem and tributaries of the Middle Fork were not investigated. Completion of the cross-sectional study surveys recommended in Appendix XI, Fish and Wildlife, for early action by 1980 would provide data from which further studies can be undertaken to determine if these projects are justified on the basis of flood damage reduction to both real property and fish propagation as well as low flow augmentation.

In lieu of the flood control and low flow augmentation measures recommended on the main-stem and tributaries of the Middle Fork for the period 1980 to 2000, a larger fish hatchery would be constructed as part of the Edfro project on the South Fork.

Skagit-Samish Basins



SKAGIT—SAMISH BASINS

DESCRIPTION OF BASINS

GENERAL

The Skagit-Samish Basins cover an area of 3,202 square miles which include 2,988 square miles of land, 55 square miles of fresh water and 159 square miles of salt water. There are three main divisions; the Skagit River drainage of 2,774 square miles (not including 400 square miles in Canada); the Samish River drainage of 139 square miles and the island and salt water area of 289 square miles.

The Basins occupy most of Skagit County, the east one-third of Whatcom County, and the north east one-fourth of Snohomish County. The principal salt water bodies include Skagit Bay (on the south) and Padilla Bay, connected by Swinomish Channel (a natural channel which separates Fidalgo Island from the mainland) and Samish Bay on the north.

Of the eleven major basins in the Puget Sound Area, the Skagit-Samish is the largest in area and in runoff. The average runoff is 11,500,000 acre-feet, annually, including 11,100,000 acre-feet from the Skagit River drainage, 200,000 acre-feet from the Samish River drainage and 200,000 acre-feet from island areas. In addition, there is an annual 700,000 acre-feet runoff from the Canadian portion of the Skagit River drainage area for a total Skagit River annual runoff of 11,800,000 acre-feet, and a total annual runoff into salt water from the Skagit-Samish Basins of 12,200,000 acre-feet.

Fidalgo and the other basin islands in the Olympic Mountain "rain shadow" have an average annual rainfall of less than 20 inches. The effects of the Olympic Mountains disappear inland as the orographic lifting of maritime air on the windward foothill slopes and higher elevations of the Cascade Mountains causes a gradual increase in annual precipitation to more than 140 inches on the wettest slopes of the Cascades. Winter snowfall ranges from about 6 inches on Fidalgo Island to more than 500 inches at the higher elevations of the Cascade Mountains.

Streamflow characteristics and other related hydrologic data for the Basin are discussed in detail in Appendix III, Hydrology and Natural Environment. The physiographic characteristics are discussed in more detail in Appendix V, Water-Related Land Resources.

PRESENT SITUATION

Local Economy

Approximately 57,000 people reside in the Basins. Over half of the population is rural with the remainder clustered around the cities of Anacortes, Mount Vernon, Sedro Woolley, Burlington, and Concrete. Anacortes, the largest city, has a population of 8,750, and Mount Vernon, the seat of Skagit County, has a population of 8,400. Table 4-1 gives historical population statistics for the Basins and principal cities and towns.

TABLE 4-1. Historical population, Skagit-Samish Basins

	1940	1950	1960	1967
Skagit-Samish Basins	37,700	43,300	51,400	56,900
Principal cities and towns:				
Anacortes	5,875	6,920	8,410	8,750
Mount Vernon	4,280	4,230	7,920	8,400
Sedro Woolley	2,950	3,300	3,700	3,850
Burlington	1,632	2,350	2,970	3,080
Concrete	859	760	840	700

Source: Appendix IV, Economic Environment, Appendix V, Water-Related Land Resources.

Agriculture, timber production and fishing and related activities have long been important to the economy. Important factors in recent population growth may be attributed to the manufacture of food and kindred products, lumber, wood products, pulp and paper, chemical products, oil refining, iron and steel manufacturing, and semi-public enterprises. Recreation, including boating, stream and lake fishing, and other water, forest and mountain activities are important activities. The proximity to deep salt water is important to Anacortes Harbor which accom-

modates foreign and domestic shipping, including the receipt of shipment of petroleum and petroleum products.

Land Use

Within the Skagit-Samish Basins, there is a total of 1,912,600 acres of land. The present land use is tabulated in Table 4-2 and shown on Figure 4-1.

TABLE 4-2. Present land use, Skagit-Samish Basins

Land Use	Acres	Percent
Forest[1]	1,753,400	91.7
Range	19,800	1.0
Cropland	100,500	5.3
Rural nonfarm	20,100	1.0
Intensive	18,800	1.0
Total	1,912,600	100.0

[1] Includes alpine and other nonforested lands normally associated with forest.

Source: Appendix V, Water-Related Land Resources.

Forests are the largest users of land, with 91.7 percent of the land in this category. Cropland which accounts for 5.3 percent of the land use, is largely located on the fertile bottomlands of the Skagit and Samish River valleys and adjacent nearly level and rolling glacial terraces. Approximately 87 percent of the agricultural lands are used for production of forage (pasture, hay, and silage) to support dairy and livestock industries. The remaining 13 percent of the agricultural land is used for production of vegetables, small grain, nursery products, berries, and field crops.

The urban and built-up lands total 1 percent and consist of residential areas, industrial, public and semi-public use areas and reserved open space. Intensive land use (see Appendix V, Water Related Land Resources) is distributed in acres as follows: railroads 800; roadways 8,300; airports 600; and urban (built-up) 9,100; a total of 18,800 acres.

The areas of intensive development are in the vicinity of Anacortes, Mount Vernon, Burlington, and Sedro Woolley. Residential areas are developing on the hill lands east of Mount Vernon. Rural residential areas are developing on the Skagit River flood plain west of Mount Vernon, and between Burlington and Sedro Woolley.

Land ownership distribution is shown in Table 4-3.

TABLE 4-3. Land ownership, Skagit-Samish Basins

Ownership	Percent
Private	17.1
Private Corporate	5.8
Federal	71.2
State	5.5
Local Government	0.9
	100.0

Source: Appendix V, Water-Related Land Resources.

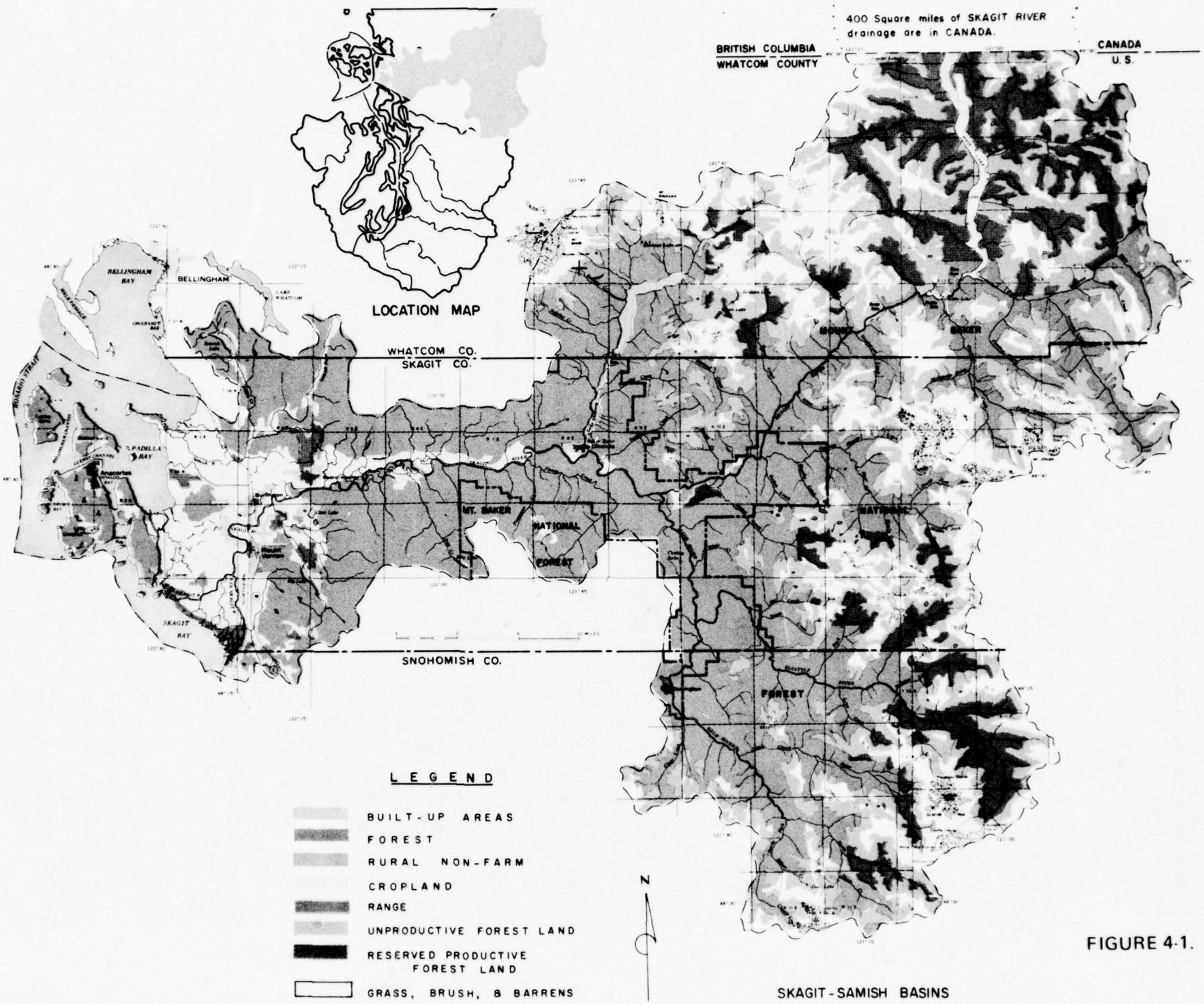


FIGURE 4-1.

SKAGIT-SAMISH BASINS
GENERALIZED LAND USE MAP

TABLE 4-4. Economic projections, Skagit-Samish Basins

	1963	1980	2000	2020	Average Annual Growth Trends (Percent) 1963 To 1980	1980 To 2000	2000 To 2020	1963 To 2020
North Division								
Population (1000's)	151.0	186.5	250	342	1.2	1.5	1.6	1.4
Employment (1000's)	45.5	58	78	107	1.4	1.5	1.5	1.5
Gross Regional Product (1,000,000's 1963 $)	369.0	848	1,800	3,977	5.0	3.9	4.0	4.3
Skagit-Samish Basins								
Population (1000's)	53.8	64.2	86.5	118.2	1.0	1.5	1.6	1.4

Source: Appendix IV, Economic Environment, Appendix V, Water-Related Land Resources.

PROJECTED ECONOMY AND LAND USE

Local Economy

Tabulated in Table 4-4 is a forecast of population, employment and gross regional product for the North Division (Whatcom, Skagit and San Juan Counties) and population for the Skagit-Samish Basins, with the forecasts translated into average annual growth trends.

Future Land Use

The projected land use of the Skagit-Samish Basins for 2020, shown on Figure 4-2, is compared in Table 4-5 with present land use. The Skagit-Samish Basins are projected to have an intensive land use density increase from the present 2.8 persons per acre to 5.0 persons per acre by 2020.

A large portion of the increase in intensive land use is expected to occur in the vicinity of Anacortes. Industrial land would be needed to accommodate expanding and new wood processing facilities, paper and pulp industries, oil refining, primary metals and other industrial uses. Additional industrial lands on the waterfront would be needed for port terminal expansion. Intensive land uses are also expected to develop along Interstate 5 and near Skagit flood plain cities. Early implementation of flood plain zoning would ensure that construction in the flood plain is compatible with the flood rise and would aid in the retention of fertile lands for agricultural use.

TABLE 4-5. Present and projected[1] land use, Skagit-Samish Basins (acres)[2]

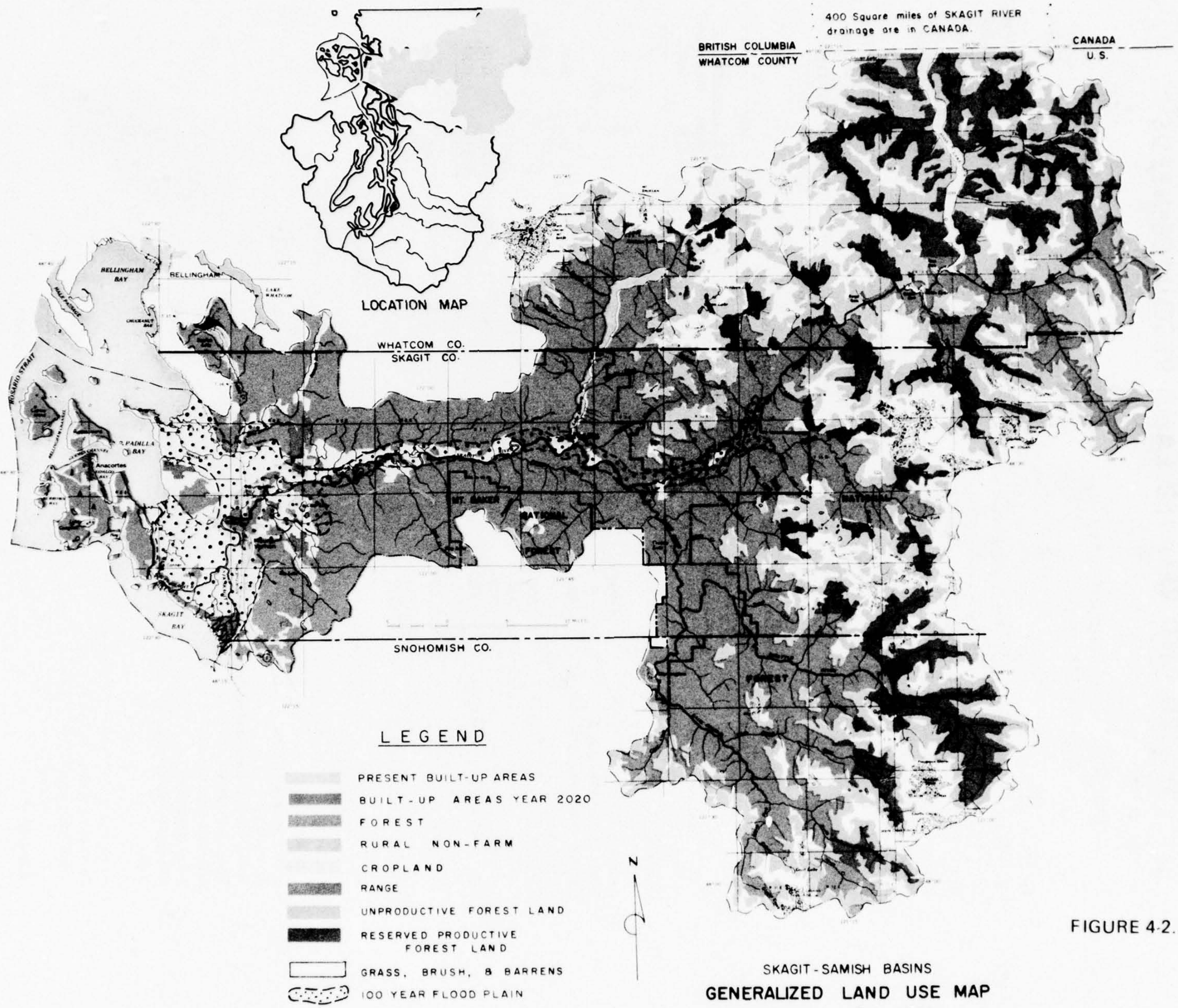
Land Use	1967	1980	2000	2020
Forest	1,753,400	1,752,600	1,752,300	1,751,800
Range	19,800	19,800	19,700	19,700
Cropland	100,500	99,600	98,500	97,700
Rural non-farm	20,100	20,000	19,900	19,800
Intensive	18,800	20,600	22,200	23,600
Total	1,912,600	1,912,600	1,912,600	1,912,600
Population (in 1000's)	56,900	64,200	86,500	118,200
Density[3]	2.8	3.1	3.9	5.0

[1] Alternative land use pattern C_2, see Puget Sound Area.

[2] Figures rounded to nearest hundred.

[3] Persons per intensive land use acre.

Source: Appendix V, Water Related Land Resources.



SKAGIT-SAMISH BASINS
GENERALIZED LAND USE MAP
Alternative C2 –2020

FIGURE 4-2.

MUNICIPAL AND INDUSTRIAL WATER SUPPLY

General

Municipal and industrial (M&I) water use in 1965 averaged about 26.3 million gallons daily (mgd) from surface supplies and 1.6 mgd from groundwater sources. The main water purveyors are the Anacortes Municipal System and Skagit County Public Utility District No. 1 (PUD No. 1). Their customers use an average of 15.4 and 8.9 mgd, a total of 24.3 mgd, all from surface supplies. The use of surface water by small municipal, industrial and private systems totaled about 2 mgd. The small communities and rural individual use amounts to 1.6 mgd.

Anacortes obtains its water from two Ranney wells located in the vicinity of Avon on the east bank of the Skagit River near Mount Vernon. This supply is supplemented during summer months by pumping directly from the Skagit River. Skagit County PUD No. 1 water is obtained principally from small streams in the Cultus Mountain watershed lying at the western extremity of the Cascade Mountains. The surface and ground water use in 1965 is summarized in Table 4-6.

TABLE 4-6. Municipal and industrial water use, 1965, Skagit-Samish Basins

System	Estimated population served	Surface water usage (mgd) Average daily	Maximum monthly	Maximum daily	Ground water usage (mgd) Average daily	Maximum monthly	Maximum daily
MUNICIPAL USE							
Anacortes	10,000	1.40	1.60	2.50	--	--	--
Skagit County PUD No. 1	23,500	2.00	2.50	3.00	--	--	--
Northern State Hospital	1,680	--	--	--	0.41	0.43	0.45
Darrington	1,400	--	--	--	0.15	0.30	0.45
Concrete	900	--	--	--	0.09	0.16	0.24
Lyman	450	0.02	0.03	0.04	--	--	--
Hamilton	200	--	--	--	0.04	0.04	0.05
Other rural community systems	2,100	0.05	0.10	0.14	0.14	0.21	0.31
Subtotal	40,230	3.47	4.23	5.68	0.83	1.14	1.50
RURAL–INDIVIDUAL USE	15,270	0.09	0.18	0.27	0.75	1.56	2.31
INDUSTRIAL USE							
Municipally supplied:							
Anacortes:							
Pulp and paper		5.50	6.00	6.10	--	--	--
Petroleum and refining		7.00	7.20	7.80	--	--	--
Chemicals		0.13	0.15	0.16	--	--	--
Naval Air Base (Whidbey Island)		1.00	1.40	1.80	--	--	--
Food processing		0.34	0.39	0.45	--	--	--
Skagit County PUD No. 1:							
Food processing		4.60	6.00	6.80	--	--	--
Chemicals, metals, oils		1.70	2.50	3.30	--	--	--
Other		0.55	0.74	0.85	--	--	--
Self-supplied:							
Food and kindred		1.68	2.20	2.80	--	--	--
Stone, clay, glass		0.27	0.30	0.40	--	--	--
Subtotal		22.77	26.88	30.48	--	--	--
Total	55,500	26.33	31.29	36.41	1.58	2.70	3.81

Source: Appendix VI, Municipal and Industrial Water Supply.

Present and Future Needs

By the year 2020, municipal and industrial water requirements are projected to reach approximately 116.4 mgd. Whidbey Island would be supplied with an additional 13.0 mgd, increasing the total demand on the water resource to 129.4 mgd.

The projected municipal and industrial water needs are set forth in Table 4-7.

TABLE 4-7. Projected municipal and industrial water needs, Skagit-Samish Basins

Year	Use	Total (Avg. Daily M.G.D.)	Total (1000's A. F. Annually)	Net Needs[1] (M.G.D.)	Net Needs[1] (1000's Acre-Feet)
1965	Municipal	4.3	4.7		
	Industrial	.8	0.9		
	Rural-Individual	22.8	25.6		
	Total	27.9	31.2		
1980	Municipal	9.2	10.1		
	Industrial	38.9	43.7		
	Rural-Individual	1.1	1.1		
	Total	49.2	54.9	21.3	23.7
2000	Municipal	14.5	16.8		
	Industrial	60.9	68.3		
	Rural-Individual	1.6	2.2		
	Total	77.0	87.3	49.1	56.1
2020	Municipal	23.2	25.8		
	Industrial	91.2	101.9		
	Rural-Individual	2.0	2.2		
	Total	116.4	129.9	88.5	98.7

[1] Cumulative total above 1965 use.

Source: Appendix VI, Municipal and Industrial Water Supply.

IRRIGATION

General

In 1965, about 6,200 acres of land were irrigated in the Skagit-Samish Basins, between Concrete and the tidelands. Approximately 4,300 acres were supplied from ground water and 1,900 acres from surface water. At this rate, average annual diversions were 12,000 acre-feet.

Present and Future Needs

Total of 95,800 acres of land are considered potentially irrigable. Including the land now under irrigation, 51,200 acres are expected to be irrigated by the year 2020. Most of the irrigated land is projected to be in the vicinity of Sedro Woolley.

The projected irrigation needs are shown in Table 4-8.

TABLE 4-8. Irrigation present status and projected needs, Skagit-Samish Basins

Year	New Irrigation (Acres)	Total Irrigation (Acres)	Total Annual Diversion (Acre-Feet)	Net Needs[1] (Acre-Feet)
1966	--	6,200	12,000	--
1980	10,000	16,200	31,100	19,100
2000	10,000	26,200	50,300	38,300
2020	25,000	51,200	98,300	86,300

[1] Cumulative annual diversion above 1966 use.

Source: Appendix VII, Irrigation.

The monthly distribution of the irrigation requirements are shown below as percent of annual demand:

May	5%	July	41%	September	8%
June	12%	August	33%	October	1%
				Total	100%

WATER QUALITY CONTROL

General

Prior to 1970 surface water quality data was collected from the Skagit River at Marblemount near Mount Vernon, and from the Samish River near Burlington. The chemical quality of the surface waters is generally excellent. The quality in the Skagit River progressively decreases downstream as the drainage area becomes more inhabited. Substantial conditions exist in areas of municipal and industrial waste discharges. Because the river has a large base flow and relatively high velocity, temperatures remain low and dissolved oxygen is normally near saturation throughout its length. Water temperatures of the Samish and some of the smaller Skagit River tributaries tend to be higher during low summer flows.

Present municipal and industrial waste discharges are shown in Table 4-9.

Present and Future Needs

State-Federal water quality standards provide the baseline from which present and future needs for water quality control are determined. The water quality classification established by the State for each watercourse in the Basins are outlined in Appendix XIII, Water Quality Control. Present and future water quality control needs are for compliance with objectives defined in the State standards. Substandard water quality conditions exist in the vicinity of municipal and industrial sewer outfalls at Anacortes and in the lower Skagit River downstream from Mount Vernon and Burlington. Wastes associated with livestock production require investigation to determine their significance in contributing to the total bacterial count in the river. Silt from gravel washing operations is controlled under provision of waste discharge permits. However, sedimentation resulting from logging and from road construction is a major source of water quality impairment.

Raw municipal and industrial wasteloads, approximating one million PE are discharged essentially without treatment into fresh and marine waters. About 80 percent of this load enters Guemes Channel and 15 percent the lower Skagit River. The principal pollutants are food processing waters in the Skagit, and food processing, paper and allied products manufacturing wastes, oil refining, lumber and wood products manufacturing wastes. The present and projected wasteloads are shown in Table 4-10.

TABLE 4-9. Summary of municipal and industrial wastes, Skagit-Samish Basins, 1965

Receiving Water	Estimated Population Served	Untreated Waste PE	Seasonal Untreated Waste PE	Treatment	Normal Waste Discharge PE	Seasonal Waste Discharge PE
Skagit River						
Diablo	265	265	--	Primary	150	--
Newhalem	225	225	--	Primary	180	--
Sedro Woolley	3,500	6,000	--	Primary	4,200	--
Metals	--	75	--	Oil, separ.	56	--
Food processing	--	800	--	None	800	--
Burlington	3,000	3,600	--	Secondary	800	--
Food processing		5,700	--	None	5,700	--
Food processing		--	40,200	None	--	40,200
Mount Vernon	8,000	13,000	--	Primary	9,000	--
Food processing		8,300	66,000	None	8,300	66,000
Avon						
Food processing		8,200	10,000	None	8,200	10,000
Samish River						
Edison						
Food processing		1,900	--	None	1,900	--
Guemes Channel						
Anacortes	7,000	8,000	--	Primary	4,800	--
Food processing		800	39,820	None	800	39,820
Paper and allied		778,000	--	None	778,000	
Oil refining		2,000	--	Secondary	500	
Fidalgo Bay						
Lumber & wood		6,000	--	None	6,000	--
Oil refining		2,000	--	Secondary	600	
Padilla Bay						
Chemicals				Neutralization		
Skagit Bay						
Skagit Co. SD no. 1		250		Primary	150	
Swinomish Slough						
La Conner						
Food processing		--	37,700	None	--	37,700
TOTAL	21,990	845,115	193,720	--	830,170	193,720
Municipal	--	31,340	--	--	19,320	--
Industrial	--	813,775	193,720	--	810,850	193,720

Source: Appendix XIII, Water Quality Control

TABLE 4-10. Present and projected raw wasteloadings, Skagit-Samish Basins (1000's PE)

Year	Municipal	Industrial	Recreational	Total	Net Need[1]
1965	31	998	19	1,048	1,027
1980	60	1,792	29	1,881	1,860
2000	87	2,210	55	2,352	2,331
2020	126	1,837	100	2,063	2,042

[1] Cumulative raw wasteload requiring treatment above that receiving treatment in 1965.

Source: Appendix XIII, Water Quality Control

NAVIGATION

General

There are two port districts in the Skagit-Samish Basins. The Port of Anacortes includes the water and lands around Padilla Bay and all land and water areas in Skagit County westerly of the center of Swinomish Channel. The remainder of Skagit County is in the Port of Skagit County.

Navigation features include natural and deep water channels and harbors and improved shallow channels and harbors mainly in marine waters. Navigation of the Skagit River is confined mainly to log raft tows, occasional barge tows to Mount Vernon and Sedro Woolley and recreational navigation throughout a great portion of the stream to Marblemount. The deeper water is in the North Fork distributary. Access to and from salt water is feasible only during higher tide stages.

The principal harbor, at Anacortes, is on Guemes Channel at the north end of Fidalgo Islands. Most of the tonnage emanating from Anacortes Harbor is from two large petroleum refinery terminals at the north end of March Point.

Present and Future Needs

The City and the Port of Anacortes propose a new channel dredged from about one-half mile south from Guemes Channel to Fidalgo Bay. The channel would serve a proposed urban renewal project on the east side of Anacortes.

Deepening of the various channels to accommodate increasing ship sizes and allow expanded navigational use of contiguous waters is necessary for the retention and growth of commerce.

Small boat harbors adequately protected from storms are needed to provide safe moorage for recreation craft. Pleasure boat needs and projected commerce are shown in Table 4-11. Table 4-12 shows harbor and channel requirements, and terminal and industrial land needs.

TABLE 4-11. Projected pleasure boating needs and waterborne commerce, Skagit-Samish Basins

	Small Boat Wet Moorages			Waterborne Commerce (1000's Short Tons)	
Year	Total	Net Needs[1]	Year	Total	Net Needs[2]
1966	1,720	1,165	1963	6,500	--
1980	2,400	1,845	1980	8,700	2,200
2000	3,930	3,375	2000	12,700	6,200
2020	6,540	5,985	2020	30,100	23,600

[1] Cumulative needs above the 555 wet moorages available in 1966.

[2] Cumulative waterborne commerce above total for 1963

Source: Appendix VIII, Navigation.

TABLE 4-12. Harbor and channel and terminal and water transport-oriented industrial land requirements, Skagit-Samish Basins

	Harbor & Channel Req. (vessel draft in feet)			Term. & Ind. Land (acres)	
Year	Freighters	Bulk Carriers	Tankers	Total	Net Needs[1]
1963	--	--	--	1,300	--
1980	39	44	45	2,900	1,600
2000	40	71	47	4,000	2,700
2020	40	71	48	5,900	4,600

[1] Cumulative needs above 1963 land use.

Source: Appendix VIII, Navigation.

POWER

General

The eight hydroelectric power generating plants in the Skagit-Samish Basins are tabulated below:

Existing Hydroelectric Plants

Name	Installed Capacity (kw)	Usable Storage (acre-feet)
Ross	360,000	1,023,000
Diablo	120,000	61,000
Gorge	134,400	7,000
Newhalem	2,000	--
Upper Baker Dam	94,400	221,000
Bear Creek No. 1	1,800	--
Bear Creek No. 2	200	--
Lower Baker	64,000	142,000
Total	776,800	1,454,000

Present and Future Needs

The electrical power needs are expected to grow even faster than the rate of population expansion. Additional power generation and transmission facilities would be required to meet these needs. There are a number of sites in the Basins having a potential for hydroelectric power development. These include pumped-storage sites as well as multiple-purpose storage sites where power could be provided as a project purpose.

A number of thermal nuclear power plants would be required in addition to power supplied from the Pacific Northwest regional system to meet the future needs of Puget Sound Area. The exact number of nuclear-fired power plants to be located in the Skagit-Samish Basins is unknown at this time. Further studies must be conducted before specific sites can be selected. Power needs are discussed further in the Area portion of this Appendix.

FLOOD CONTROL

General

The Skagit-Samish flood plains totaling 90,000 acres include the deltas of both rivers, and reclaimed tidelands along the main-stem of the Skagit River upstream from Sedro Woolley. About 68,000 acres of fertile land lie downstream and west of the city of Sedro Woolley, and 22,000 acres of river bottom land lie east and are upstream of this community.

Principal urban developments in the flood plain are at LaConner, Conway, Mount Vernon, Burlington, Sedro Woolley, Hamilton, Rockport and Marblemount. The major industries in these towns are based on agriculture and forest products except for manufacturing in Sedro Woolley.

The entire levee system downstream from the Burlington-Mount Vernon area, including both North and South Forks, has been constructed piecemeal over a long period of time. At the present time 16 diking districts maintain 56 miles of levees along the Skagit and Samish Rivers and 39 miles of sea dikes to protect 45,000 acres of land. Private levees and dikes totaling 16 miles in length protect an additional 1,000 acres.

Only the reservoir above Ross Dam provides a significant amount of flood control. It has about 1,023,000 acre-feet of usable storage, of which 120,000 acre-feet are reserved for flood control. The effectiveness of this storage in reducing peak discharges is variable. Under average conditions, Ross Dam would reduce flood crests by 15,000 to 25,000 cfs at Sedro Woolley.

The upper Baker Dam and Reservoir has 16,000 acre-feet of flood storage to compensate for natural channel storage lost by construction of the Dam. Flows are regulated to avoid increasing floods above natural conditions but neither the upper or lower Baker Dams provide dependable flood control for the lower river.

In the agricultural setting of the Skagit Valley, the greater part of the past flood damages have been to lands and crops. In the delta area, breaching of tidal dikes by impounded flood waters present special damage problems because salt water flooding through the breached dikes may reduce productivity of farm lands for one to ten years.

A flood of the size which occurred in 1921 would cause an estimated $20,820,000 in damages at 1966 prices and conditions. The average annual damages for all floods in the flood plain downstream from Marblemount are estimated at about $3,020,000.

Table 4-13 lists the peak discharges and recurrence intervals of recent major floods at Concrete. Estimated flood damages are based on 1966 prices and conditions.

TABLE 4-13. Major floods and estimated damages, Skagit-Samish Basins

	Peak Discharge of Skagit River at Concrete (cfs)	Average Recurrence Interval (years)	Current Estimated Damages
30 Nov 1909	260,000	100	$22,170,000
13 Dec 1921	240,000	81	20,820,000
27 Nov 1949	154,000	14	9,090,000
10 Feb 1951	139,000	10	16,650,000

Source: Appendix XII, Flood Control.

Present and Future Needs

The level of flood protection in the lower delta is inadequate for optimum farm development with reasonable freedom from flood danger. Levees protecting Mount Vernon, Burlington, Sedro Woolley and Conway provide a degree of protection considerably below that suitable for urban development. Also, isolated farms east of Sedro Woolley and the communities of Lyman and Hamilton are inadequately protected.

Average annual damages are forecast to reach $4,340,000, in 1980, $7,060,000 in 2000, and $12,030,000 in 2020 unless flood control is provided. Flood plain regulation would be only partially successful in slowing flood plain development. Consequently, there is an urgent need for structural measures to reduce flood damages to existing development, and of strong land use controls to restrict the build-up of urban, residential, commercial and industrial structures in the flood plain. Projected flood damage reduction needs are summarized in Table 4-14

TABLE 4-14. Projected flood damage reduction needs,[1] Skagit-Samish Basins

Year	Total ($1000)	Net Needs[2] ($1000)
1966	3,020	3,020
1980	4,340	4,340
2000	7,060	7,060
2020	12,030	12,030

[1] Based on 1966 prices and conditions.

[2] Damages which would occur without additional measures.

Source: Appendix XII, Flood Control.

WATERSHED MANAGEMENT

General

The need in the Skagit-Samish Basins is for implementation of integrated programs and projects for floodwater damage reduction and water management, with rehabilitation and protection of watershed lands regardless of use. The implementation of integrated programs and projects would meet the primary objectives, improve the quality of municipal and industrial water, enhance fish and wildlife habitat, provide opportunities for recreation, and improve the general environment.

Present and Future Needs

The needs for watershed management are complex and two or more practices and measures may be required on the same area of land. Many measures and treatments become involved in integrated programs and projects. The broad needs for improved technology programs and projects are given under Area. The watershed management needs are tabulated in Table 4-15.

TABLE 4-15. Total watershed management needs, Skagit-Samish Basins

Year	Flood Prevention[1] (acres)	Watershed Protection and Rehabilitation (acres	Water Management Agricultural (acres	Water Management Urban (acres)
1980	120,900	1,912,600	49,000	38,900
2000	120,900	1,912,600	81,700	38,900
2020	120,900	1,912,600	108,900	38,900

[1] Includes flooding on mainstreams but not forested land within flood plain areas.

Source: Appendix XIV, Watershed Management.

RECREATION

General

The Skagit-Samish Basins have mountains, wilderness, streams, lakes, salt water areas and shorelands, which afford many and varied recreational opportunities. Features of special significance are the Skagit River valley, with natural beauty and large salmon and steelhead runs, and the rugged forested

mountains with the North Cascades National Park, the Ross Lake National Recreation Area, the Pasayten and Glacier Peak Wilderness Areas. Also the salt water areas include unique Deception Pass with its swirling waters and unusual sites, the naturally-formed and federally-maintained Swinomish Channel and the many islands and the popular sport fishing.

The total area of the Skagit River Basin within the United States is about 1,770,000 acres. Of this amount 77 percent of 1,384,000 acres are within the Mount Baker National Forest, the North Cascade National Park, the Ross Lake National Recreation Area, the Pasayten and Glacier Peak Wilderness Areas. The entire area and considerable additional State and private forest lands are available for recreational use.

There are 124 publicly-administered outdoor recreation sites within the Basin, including those in the North Cascades National Park and Ross Lake National Recreation Area. Seventy-eight are administered by the Federal Government, 34 by the State, and 12 by the cities. In addition, there are 16 private operations offering recreational facilities for public use.

During 1964 there were 1,436,000 visits on publicly-administered areas reported. Of these, 1,125,000 were to State areas and 160,000 were to Forest Service Areas.

Wild and Scenic Rivers Act

A major consideration in planning for the Skagit-Samish Basins is the possible future inclusions of portions of the Skagit River and its tributaries in the national wild and scenic rivers system in accordance with the Wild and Scenic Rivers Act (P.L. 90-542, October 2, 1968)

The stream reaches of the Skagit River Basin to be studied under the Act in an investigation subsequent to this study are further identified as follows:

Streams to be Studied for Potential Addition to the Wild National & Scenic River System

River	Reach	Length (Miles)
Skagit	Mount Vernon to and including the mouth of Bacon Creek	70
Cascade	Mouth to junction of its North & South Forks	17
Cascade, South Fork	Mouth to Glacier Peak Wilderness Area	2
Suiattle	Mouth to Glacier Peak Wilderness Area at Milk Creek	28
Sauk	Mouth to junction with Elliot Creek	38
Sauk, North Fork	Mouth to Glacier Peak Wilderness Area	10
	Total	165

A forecast is impossible of the river reaches which could be included by Congress in the Wild and Scenic Rivers system, or of the restrictions on developments, existing or future, which could apply to these reaches. However, the wording of the Act indicates that no future impoundments or similar water resource projects would be permitted on the reaches included in the system, except that minor improvements such as levees may be permitted along reaches designed as Recreational River Areas. There-

fore, careful consideration must be given to proposed future developments in the Skagit Valley as to the extent and classification of reaches to be designated as part of the system.

The Wild Scenic Rivers study will include consideration of data developed for this report and summarized herein. Close cooperation will be maintained with the State of Washington and its political subdivisions, and, if so requested by the State, the study will be carried on jointly with any appropriate State or local agency. The Wild and Scenic Rivers study will consider the following items:

(1) Characteristics which would qualify the area for inclusion in the system.

(2) Current status of land ownership.

(3) Present land use.

(4) Foreseeable potential uses of land and water which would be enhanced, foreclosed, or curtailed if the area is included in the system.

(5) Proposed administering agency or agencies and the extent to which administration would be shared by the State and/or local agencies.

(6) Estimated acquisition and administration costs.

If segments of the Skagit River, or its Cascade, Sauk, and Suiattle River tributaries, become components of the Wild and Scenic Rivers System, such designation could preclude certain types of water resource projects, depending on the classification given, as discussed in Section 7 of the Act. Selected excerpts from the Act are contained at the end of the Skagit-Samish Basins discussion as an Exhibit.

Present and Future Needs

The present and future water related recreation needs, in terms of recreation days annually, are shown in Table 4-16.

TABLE 4-16. Present and projected water-related recreation demand, Skagit-Samish Basins (1000's recreation days)

Year	Total	Net Needs[1]
1960	2,200	900
1980	4,300	3,000
2000	8,300	7,000
2020	15,200	13,900

[1] Cumulative needs above 1,300,000 recreation days satisfied by facilities existing in 1960.

Source: Appendix X, Recreation.

The 1960 supply of developed lands was inadequate to satisfy boating, camping and picnicking demands of that year. In addition to lands developed for boating facilities, an additional 1,188 rental moorage spaces were needed in 1966 to satisfy boating demands. There are enough natural waters to satisfy water based recreation demands until 2010. After that year a portion of the surplus water use

may be transferred to the adjacent Whidbey and Camano Islands.

In addition to indicated needs, urban parks, scenic routes, waterfront access, recreation rivers, special interest areas, interpretive facilities, open spaces, and beaches and trails for activities other than swimming and hiking are necessary to satisfy the recreation and environmental needs of the people.

FISH AND WILDLIFE

General

The Skagit-Samish Basins are dominated by the Skagit River and its tributaries which support a major portion of the Area's anadromous fish runs. The Samish is a smaller, but important fish producer. The salt water portion of the Basins, together with the estuaries are vital fresh-salt water conversion areas for this fishery. The main streams and salt water areas are important for sport fishing. An important commercial fishery exists in the salt water areas, but the major commercial catches, as well as important sport catches, are made in salt water areas outside the Basins and outside the Puget Sound Area.

A good fresh water resident fishery and harvests of bottom and shellfish are other assets.

Because of vast primitive, forested, mountainous areas, open lowlands and expansive delta, the Basins are the major game producers.

Present and Future Needs

There is a need to retain and expand fishing opportunities for trout, steelhead, salmon and other species in the Skagit-Samish Basins. Similarly there is a need to provide opportunities for hunting commensurate with population growth. The projected fishing and hunting needs for the Basins are shown in Table 4-17.

TABLE 4-17. Fish and wildlife, sport and commercial needs, Skagit-Samish Basins

	Unit	1965 Total	1980 Total	1980 Net[1]	2000 Total	2000 Net[1]	2020 Total	2020 Net[1]
Sport Fishing								
Salmon	1000 User-Days	100	166	66	306	206	519	419
Game Fish	1000 User-Days	747	1,248	581	1,961	1,214	3,138	2,391
Marine Fish	1000 User-Days	2	3	1	4	2	5	3
Shellfish	1000 User-Days	11	15	4	20	9	26	15
Total		860	1,432	572	2,291	1,431	3,688	2,828
Hunting	1000 User-Days	159	307	148	498	339	614	455
Commercial Fishing	1000 Pounds			360		3,692		7,940

[1] Cumulative need above 1965 activity.

Source: Appendix XI, Fish and Wildlife.

COMPREHENSIVE PLAN

BASIS OF PLANNING

Desires of Local People

Objectives, needs, and opportunities for Skagit-Samish Basins water resource development were voiced at the hearing held in Anacortes on October 12, 1964. A primary concern was the need for flood control in the delta below Sedro Woolley. Also expressed were the needs for additional water supply for the city of Anacortes and the Skagit River Valley, watershed management, additional power site development, marine and riverside recreation site developments, and channel dredging in Fidalgo Bay. Further expression was for the preservation of sea dikes along the Swinomish Channel during maintenance dredging operations, and the preservation of the existing fishery and recreation features. Organizations and individuals desiring preservation of natural environment opposed construction of new upstream storage sites (see Appendix I, Digest of Public Hearings).

Summary of Basin Needs

The needs of the Skagit-Samish Basins for 1980, 2000, and 2020 are summarized in Table 4-18.

General Planning

A wide range of alternative nonstorage and management opportunities were viewed to meet the water supply needs of the Skagit-Samish Basins. These included diversion structures, direct river pumping and treatment, desalinization, interbasin water transfer, further ground water utilization, and improved water yields through various watershed management practices. Levees, channelization, diversion, flood plain management, bank protection, and improved land use management practices were

TABLE 4-18. Summary of needs, Skagit-Samish Basins

Feature	Units	Cumulative Net Needs[1] 1980	2000	2020
M&I Water Supply	mgd	21.3	49.1	88.5
	(1000 Ac.Ft.)	(23.7)	(56.1)	(98.7)
Irrigation	1000 Ac.Ft.	19.1	38.3	86.3
Water Quality Control				
Waste	1000 Pop. Equiv.	1,860	2,331	2,042
Flow[2]	cfs	240	435	650
Navigation				
Commercial	1000 Short Tons	2,200	6,200	23,600
Pleasure Boats	Wet Moorages	1,845	3,375	5,985
Power[3]				
Flood Control	$1000 Damage Reduction	4,340	7,060	12,030
Watershed Management				
Flood Prevention	1000 Acres	120.9	120.9	120.9
Watershed Protection & Rehabilitation	1000 Acres	1,912.6	1,912.6	1,912.6
Water Management				
Agricultural	1000 Acres	49.0	81.7	108.9
Urban	1000 Acres	38.9	38.9	38.9
Recreation	1000 User-Days	3,000	7,000	13,900
Fish and Wildlife				
Sport				
Fishing	1000 User-Days	572	1,431	2,828
Hunting	1000 User-Days	148	339	455
Commercial	1000 Pounds	360	3,692	7,940

1 See Water Related Land Resource Needs for derivation of net needs.

2 Skagit River.

3 Power needs were projected for the Puget Sound Area only.

considered as possible means of meeting flood control and watershed management needs. Opportunities considered for satisfaction of water quality needs were sewage collection and treatment facilities and minimum flows available to assimilate residual waste-loadings. The water and related land resource was examined in terms of projected land use pattern C_2, (see Projected Land Use) with the land needs of navigation, power, recreation, open space, greenbelts, and fish and wildlife considered within this context.

There are storage sites on a number of rivers which could provide opportunities for hydroelectric power production, flood control and to more fully utilize the resource in meeting water supply needs and minimum streamflow requirements for anadromous and resident fish. Over 6,000,000 acre-feet of aggregate storage could be developed at sites on the Skagit, Baker, Sauk, and Cascade Rivers. With storage there would be sufficient quantities of water to meet projected water supply needs even during a year of extreme low runoff without reducing streamflows below historical minimums during critical periods for fish. For further information on minimum streamflows for fish see the Area discussion on Fish and Wildlife.

Alternative objectives were considered in the planning process while developing the Comprehensive Plan. The objectives represented both ends of the spectrum of interests, i.e., economic efficiency and environmental quality as discussed in the Puget Sound Area section of this Appendix. The alternative elements considered in plan formulation are described under Alternative Elements.

The single-purpose Appendices, V through XIV, provided a wide array of solutions. Necessary adjustments were made to these solutions in the formulation of comprehensive plans for the Basins. These adjustments consisted of:

(a) A flood control storage site, contained in Appendix XII, on the lower Sauk River was not used in one alternative plan for the basins. Flood plain management and an increased size of a bypass channel near Avon was used to allow for flood control below Sedro Woolley equivalent to that possible with the storage project.

(b) Fish and wildlife measures contained in Appendix XI were modified to a limited extent with additional artificial propagation facilities planned in lieu of several storage projects recommended for flood control and low-flow augmentation. Scheduling of construction of a fish passage facility at the falls on the North Fork of the Cascade River also was moved up to before 1980 in order to satisfy the level of needs projected for that year.

A major consideration in planning for the Skagit-Samish Basins was the possible future inclusion of portions of the Skagit River and its tributaries in the National Wild and Scenic Rivers system in accordance with the National Wild and Scenic Rivers Act. Pertinent portions of the Act are presented as Exhibit 1 at the end of the Skagit-Samish Basins discussion. Under the Act, the classifications "wild," "scenic," and "recreation" would impose different restrictions upon future improvements along the stream. Because of the possibility of parts of the Skagit River system being classified under the national system, two alternatives, A and B, are presented herein for consideration.

Alternative A allows full use of storage opportunities to obtain maximum flood control in the Skagit River Basin. The assumption is made under this Alternative that no part of the Skagit River or its tributaries would be included in the National Wild and Scenic Rivers system. However, portions of the Skagit River system would be included for study under a State recreational river system.

Alternative B is based on the assumption that the entire 165-mile river complex cited in the Act would be designated in the National Wild and Scenic Rivers system. Also, the assumption is made that the entire complex would be given a "Recreational River" classification and that nonstorage developments would be compatible with this classification.

The elements of the alternative plans are the same for all features except for flood control, power and recreation. The latter only differs as to the inclusion of the designated portions of the Skagit River and tributaries in a National Wild and Scenic Rivers system with development costs for recreation facilities and land acquisition assumed to be the same under both alternatives.

Stream reaches assumed to be designated under Alternative B for the National Wild and Scenic Rivers system are identified in the tabulation below:

Alternative B
Segments of the Skagit River and its Tributaries to be Considered in the National Wild and Scenic Rivers Study

		Miles
Skagit	Mount Vernon to and including the mouth of Bacon Creek	70
Cascade	Mouth to junction of its North and South Forks	17
Cascade, North Fork	Mouth to Glacier Peak Wilderness Area	2
Suiattle	Mouth to Glacier Peak Wilderness Area at Milk Creek	28
Sauk	Mouth to junction with Elliott Creek	38
Sauk, North Fork	Mouth to Glacier Peak Wilderness Area	10
		165

SUMMARY OF PLAN ALTERNATIVE A

Alternative A is presented first in the following discussion in its entirety with a discussion of Alternative B following, limited to those features which differ with Alternative A. A comparison of Alternatives A and B is presented in Comparative Evaluation of Alternatives A and B.

Early Action, 1970-1980

During this period municipal and industrial water supply needs of the city of Anacortes and the Skagit County PUD No. 1 would be satisfied by pumping and treating water from the Skagit River for the city and further withdrawal of water from the Cultus Mountain Watershed for the PUD. Ground water resources would continue to supply small and rural communities and industry.

About 10,000 acres of cropland would be placed under irrigation with water supplied by individual farmers from both surface and ground sources.

Compliance with Washington State water quality standards would be obtained through installation of adequate collection and treatment facilities by a number of communities and cities and by food processors. The paper mill at Anacortes would remove settleable solids from mill effluents prior to discharge and would install adequate outfalls and diffusers to achieve maximum dilution and dispersion into Puget Sound. A water quality surveillance program would be expanded in order to provide an adequate monitoring system with sampling stations on marine and fresh water. A comprehensive sewerage plan would be developed for the Basins.

Navigation needs would be met through deepening of Guemes channel and by providing a deep draft channel in Fidalgo Bay. These channels would be deepened to accommodate bulk petroleum vessels and freighters respectively. Lands found to be suitable for terminal or water transport-oriented industrial development would be retained for this purpose to insure future availability. Development of existing and new areas of the Port of Anacortes would begin during this period in order to provide a basis for future port expansion. Wet moorage would be provided for pleasure boaters through the construction of two small boat harbors with 850 moorage slips.

Power needs for the Basin would be satisfied by the Northwest Regional system which is discussed under Power in the Area portion of this Appendix. Additional power production is recommended for further consideration at Ross, Gorge and Diablo Dams with the raising of Ross Dam. Also recommended for further consideration is a reregulation project on the Skagit River at Copper Creek and nuclear power development sites on the salt-water shoreline.

During this period 100,000 acre-feet of flood control storage would be obtained by changing the operation of the Upper Baker project. The Avon Bypass would be sized for a flow of 60,000 cfs. A levee would be constructed at Nookachamps Creek before 1980. Flood plain management by land use zoning of lands would control development in the flood plain consistent with the levels of flood protection. Floodproofing and warning systems also would be implemented. These measures would con-

tribute significantly to the reduction of future flood damages.

Small watershed flood multiple-purpose projects at Gages Slough, South Mount Vernon, the Samish River and at the Skagit Flats watersheds are planned for implementation during this period to achieve floodwater damage reduction, protection and rehabilitation of lands, and water management. The projects include stabilized channels and outlet control structures. Programs of technical assistance, water management, land treatment and drainage, would complement structural measures.

Campgrounds, picnic areas, beaches, and boat launching ramps would be developed on existing public lands. Additional land and water areas would be acquired to satisfy recreational needs. Acquisition would include additional land along the Puget Sound shoreline to provide badly needed marine parks. Over 60 recreation areas would be expanded or developed before 1980.

Fish and wildlife enhancement projects including acquisition of access would be undertaken to increase the opportunities for this form of outdoor recreation. Additional fish hatcheries would be constructed for both resident and migratory fish together with rearing ponds, spawning channels and fish passage improvements including a collection and transportation facility to provide migratory fish access above Cascade Falls and on the North Fork of the Cascade River. Cross-sectional stream surveys would be undertaken during this period to determine the minimum and optimum streamflows required for fish production. These cross-sectional surveys may result in further studies of new projects as well as reconsideration of the operation of existing projects.

Long-Range, 1980-2020

Existing water supply systems would be expanded to meet elements of population and industrial growth. The projected water supply needs of municipalities, small and rural communities and industry would be satisfied.

An additional 45,000 acres of land would be placed under irrigation during this period with water supplied from surface and ground water. A project type development is planned by the year 2000.

Existing treatment and collection facilities would be expanded commensurate with the growth in population and industrial development. State water quality standards would be met and the water quality surveillance program would be maintained.

Further terminal and water transport-oriented industrial development is envisioned during this period to meet the navigation needs of the Basins. Lands would be developed in Padilla Bay through dredge fill as a deep-draft channel would ultimately be provided having a depth of 54 feet. Further channel dredging is planned in Fidalgo Bay. The Guemes channel would be deepened to accommodate bulk petroleum vessels.

Power development could include pumped-storage at a number of the potential sites within the Basins. Oil or gas-fueled steam electric plants also may be located during this period to meet short-time peaking requirements. Development of nuclear electric generating plants may occur but definite scheduling of facilities and exact siting have not been completed and would be dependent upon future studies of shoreline characteristics, major load centers and impacts on the environment. Power facilities would be provided as part of the Lower Sauk storage project.

After 1980 levees would provide 100-year winter flood protection for the communities of Hamilton and Sedro Woolley. These projects, generally would be a matter of raising existing structures to heights sufficient to provide the 100-year protection. Flood plain management would be continued with zoning being required to guide future development and prevent unwarranted development in the flood plain. Under Alternative A, 134,000 acre-feet of flood control storage would be provided by the Lower Sauk project.

Eight additional multiple-purpose projects would be undertaken to satisfy watershed management needs in this time period. In addition to the structural measures included in these projects, a program of technical assistance, land treatment, and water management would be continued and enlarged.

Additional development of campgrounds, picnic areas, and other recreation facilities would be undertaken after 1980 at nearly 170 sites throughout the Basins, on public lands as well as on private lands, with both public and private sectors participating in providing facilities. The recreation facilities at the Avon Bypass project would be expanded commensurate with demand. Portions of the Skagit River

system would be included in a State system of scenic and recreational rivers for retention in a free-flowing state for public use.

Additional fish and wildlife opportunities would be provided through anadromous and resident fish enhancement measures. A number of fish passage improvements are planned during the long-range period as well as additional spawning habitat development.

Table 4-19 summarizes the Skagit-Samish Basins elements of the Comprehensive Plan, showing the benefits and costs for the early action portion of the Plan, and provides a summary of investment costs by water resource functions for the entire 50-year period ending in 2020. The early action portion of the Plan includes programs amounting to $88,414,000 and projects costing $109,185,000; for a total investment of $197,599,000. Program and project investment costs for the 1980-2000 period amount to $329,905,000 and for the 2000-2020 period program and project costs would be $246,830,000. A total 50-year investment would amount to $774,334,000.

FEATURES OF THE COMPREHENSIVE PLAN ALTERNATIVE A

Municipal and Industrial Water Supply

The city of Anacortes and the Skagit County PUD No. 1, supply approximately 85 percent of the average annual water used and are expected to continue to supply about this same proportion through 2020. Anacortes currently operating near capacity is able to meet a peak maximum of 21 million gallons per day to municipal and industrial consumers. The existing system, drawing from horizontal wells in the Skagit River, receives large amounts of ground water, along with the river water, which is very high in iron. This present system would be phased out in favor of a river intake and treatment plant. Upon completion of the new source the horizontal well would be used for meeting peaks and standby service.

The Skagit County Public Utility District No. 1 should be able to meet all anticipated needs through 2020 from the Cultus Mountain watershed. The PUD would be able to deliver adequate quality water without treatment.

The major water users are expected to be centered near the more urbanized centers and would receive water from presently developed and expanded sources. The smaller rural communities are expected to continue using ground water sources as their major supply of water. The exception would be when one of the larger systems can feasibly extend its distribution system into the more sparsely populated areas. Self-supplied industry using both surface and ground water would continue expanding existing systems. The small and rural communities and self-supplied industry presently use only about 13 percent of the total Basins water.

The municipal and industrial water needs projected for 2020 can be met by the resource within the Basins without the need for storage. Although a plentiful source of surface water is available, projected population and industrial growth would require larger systems.

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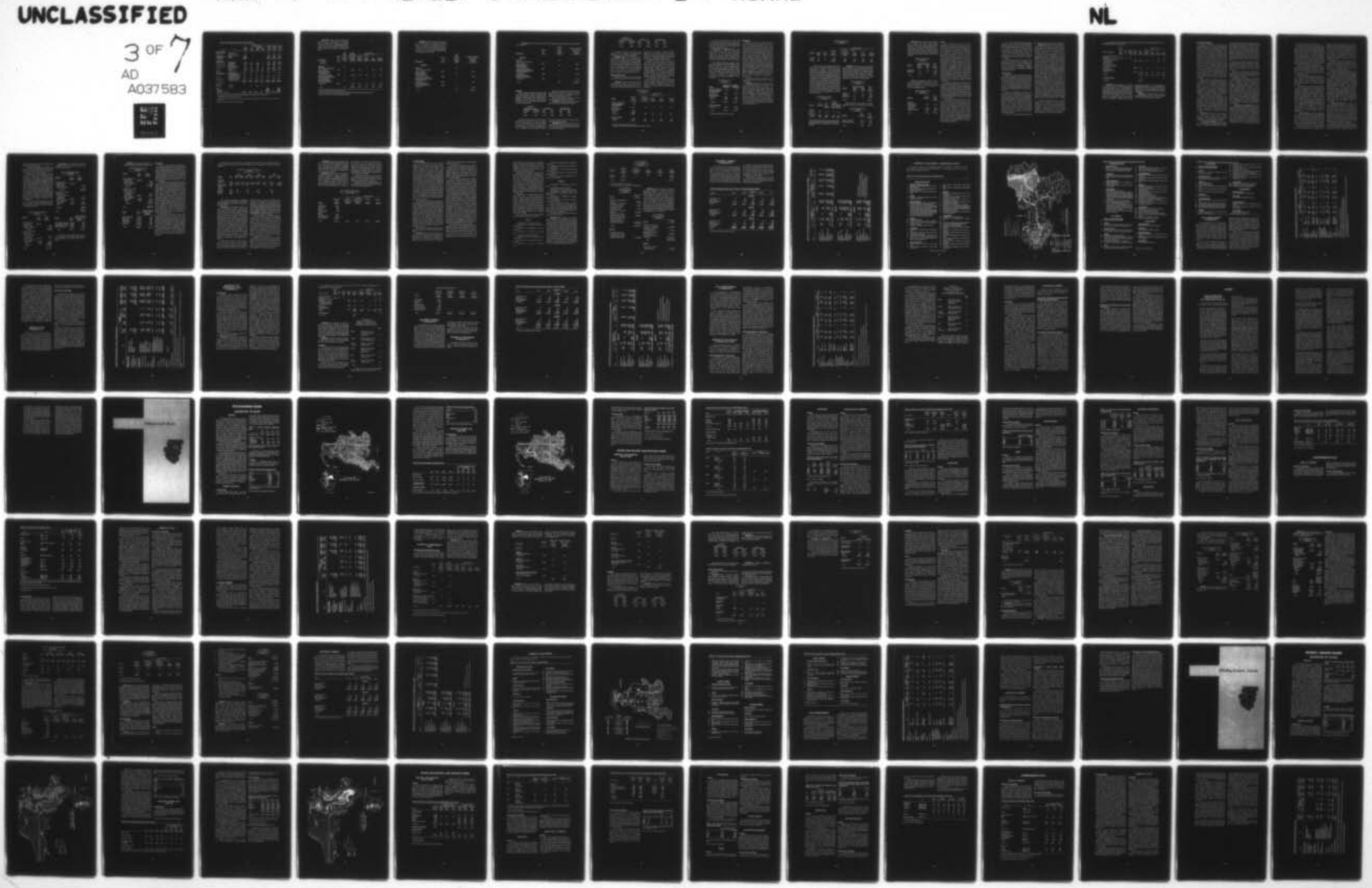
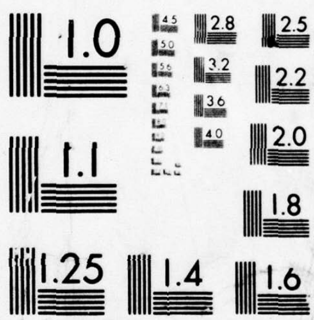




MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

TABLE 4-19. Comprehensive Plan, Alternative A, Skagit-Samish Basins

Feature	Item	1970-1980 Investment[1] Costs ($1000)	1970-1980 Average Annual Costs ($1000)	1970-1980 Average Annual Benefits Gross ($1000)	1970-1980 Average Annual Benefits Net ($1000)	1980-2000 Investment Costs ($1000)	2000-2020 Investment Costs ($1000)	1970-2020 Investment Costs ($1000)
Management Programs								
Water Quality Control	Monitoring, Evaluation and Control	490	--	--	--	360	420	1,270
Flood Control	Flood Control Management	115	--	--	--	168	168	451
Watershed Management	Programs	87,556	--	--	--	99,226	109,318	296,100
Fish and Wildlife	Programs	253	--	--	--	200	200	653
Total Programs		$ 88,414				$ 99,954	$ 110,106	$ 298,474
Nonstorage Projects								
M&I Water Supply	Ground Water Use	0	0	0	0	565	905	1,470
	Surface Water Use	5,440	503	503[4]	0	7,560	10,385	23,385
Irrigation Water Supply	Ground Water Use	1,072	179	179[4]	0	3,400	3,750	8,222
	Surface Water Use	278	46	46[4]	0	3,700	14,000	17,978
Water Quality Control	Sewerage Treatment and Collection Facilities	4,880	320	320[4]	0	8,050	8,900	21,830
Navigation	Channels	1,465	81	105	24	9,417	2,989	13,871
	Small Boat Harbors[3]	(1,714)[3]	(109)[3]	(159)[3]	(50)[3]	(3,831)[3]	(3,830)[3]	(9,375)[3]
Power[2]								
Flood Control	Levee and Channels	37,800	1,983	3,150	1,167	5,800	0	43,600
Watershed Management	Floodwater Damage Reduction, Water Management, and Protection and Rehabilitation	10,637	594	2,242	1,648	1,850	1,460	13,947
Recreation	Land Acquisition, Access and Enhancement Facilities	35,814	2,555	3,600	1,045	42,700	71,300	149,814
Fish and Wildlife	Land Acquisition, Access and Enhancement Facilities	11,799	1,420	1,910	490	18,909	23,035	53,243
Total Nonstorage		$109,185	$7,681	$12,055	$4,374	$101,951	$136,724	$347,860
Storage Projects								
	Upper Baker							
Flood Control			133	300	167			
	Lower Sauk							
Power						68,000		68,000
Flood Control						60,000		60,000
Total Projects						$128,000		$128,000
Total Programs and Projects		$ 197,599	$7,814	$12,355	$4,541	$329,905	$246,830	$774,334

[1] Includes cumulative annual program costs for the period for management features and capital costs for nonstorage projects.

[2] Nonstorage power development not included in the Plan.

[3] General navigation facilities costs and benefits for public small boat harbors only. Total pleasure boat facilities costs and benefits included with Recreation.

[4] Average annual benefits assumed equal to average annual costs.

1970-1980—Under the early action phase of the Plan existing water supply systems in the Basins would be enlarged and expanded. The projected average daily water use for the Skagit-Samish Basins, planned supply and transmission investments and average annual costs are shown in the tabulation below:

Development	Needed by Year	1980 Average Daily Water Use (mgd)	Supply, Transmission & Treatment Investment ($1000)	Average Annual Costs: Interest & Amort.[1] ($1000)	Average Annual Costs: O&M[2] ($1000)	Average Annual Costs: Total ($1000)	Average Annual Benefits[3] ($1000)
1970-1980							
Anacortes		28					
River intake and treatment plant expansion	1975		3,075	243	3	246	246
Skagit Co. PUD No. 1		15					
Cultus Mountain watershed development	1970		2,050	162	68	230	230
Small and Rural Communities		0					
No additional need			0	1	1	1	1
Self-Supplied Industry		3					
Surface or ground water development	1980		315	25	1	26	26
Total		46	$5,440	$430	$73	$503	$503

[1] Interest and amortization of capital investment costs.

[2] Total incremental increase in annual operation and maintenance costs, including pumping and treatment costs.

[3] Average annual benefits assumed equal to average annual costs.

1980-2000–During this period further expansion of existing systems would take place commensurate with population and industrial growth. A summary of projected average daily water use and investment costs is shown in the following tabulation for municipal and industrial water supply developments required by the year 2000.

Development	Needed by Year	2000 Average Daily Water Use (mgd)	Supply, Transmission and Treatment Investment ($1000)
1980-2000			
Anacortes		40	
River intake and treatment plant expansion	1995		3,075
Skagit Co. PUD No. 1		26	
Cultus Mountain watershed development	1990		4 ,100
Small and Rural Communities		2	
Local ground water development	1990		180
Self-Supplied Industry		6	
Surface or ground source development	2000		770
Total		74	$8,125

2000-2020–Basins needs through 2020 would be supplied by further expansions of existing systems as shown below:

Development	Needed by Year	2020 Average Daily Water Use (mgd)	Supply, Transmission and Treatment Investment ($1000)
2000-2020			
Anacortes		54	
River intake and treatment plant expansion	2015		3,670
Skagit Co. PUD No. 1		43	
Cultus Mountain watershed development	2010		6,050
Small and Rural Communities		4	
Local ground water development	2010		240
Self-Supplied Industry		11	
Surface or ground source development	2020		1,330
Total		112	$11,290

Irrigation

Future irrigation development by private means would likely continue through 1980. After 1980, irrigation development could be accomplished by pumping from the Skagit River through project distribution systems. The peak surface diversion demand of 25 cfs from the Skagit and Samish Rivers can be met without storage.

Lands under irrigation are projected to increase by 45,000 acres during the next 50 years. In the Basins, about 43 percent of irrigated land would ultimately be supplied by ground water.

Irrigation development as provided for in the Comprehensive Plan is discussed by periods:

1970-1980–The following tabulation shows the amount of ground and surface water required:

1970-1980 New Irrigation Area		Diversion		Net Depletions	
GW Supply (Acres)	SW Supply (Acres)	GW (AF)	SW (AF)	GW (AF)	SW (AF)
8,000	2,000	15,100	4,000	14,900	3,700

The private investment cost for the new surface and ground water diversions is estimated at $135 per acre for total investment cost of about $1,350,000 with total average annual charges, including interest and amortization, and operation and maintenance costs of $120,000, equal to $224,900. The investment costs include provisions for on-farm sprinkler system and pumping equipment.

1980-2000–During this period further diversion would be provided through project-type developments by pumping directly from the Skagit River and from wells as shown below:

1980-2000 New Irrigation Area		Diversion		Net Depletions	
GW Supply (Acres)	SW Supply (Acres)	GW (AF)	SW (AF)	GW (AF)	SW (AF)
5,000	5,000	9,200	10,000	9,300	9,300

The private investment cost for the on-farm sprinkler system is estimated at $1,100,000 with Federal project costs estimated at $6,000,000.

2000-2020–During the last 20 years of the planning period, 25,000 acres of additional land are projected to be irrigated. Irrigation water supplies would be provided by diversion of 30,000 acre-feet from surface water and 10,000 acre-feet from ground water. The estimated investment costs of the diversion facilities, pipelines, and on-farm distribution facilities is $17,750,000 of which $2,750,000 is private investment for on-farm sprinkler systems. Peak surface diversion by 2020 would be 255 cfs.

Water Quality Control

Water quality control elements of the Comprehensive Plan are described by the following periods:

1970-1980–During this period Mount Vernon, Sedro Woolley, Concrete and the properties of Seattle City Light would provide adequate secondary treatment facilities with disinfection. The city of Burlington would expand or modify its domestic system. The town of LaConner, the nearby Swinomish Indian settlement, and Skagit County Sanitary District No. 1 would install secondary treatment and disinfection facilities and an adequate outfall.

Adequate secondary treatment of waste discharges by food processors would be undertaken or the wastes would be intercepted by a municipal system. The paper company at Anacortes would provide primary treatment facilities to remove all settleable solids from mill effluents with adequate facilities installed for the disposal of recovered solids or sludge together with a submarine outfall with diffuser. The fish canneries and wood products industries would also provide adequate treatment of their wastes during the early action period.

The investment costs of waste treatment and collection facilities called for by 1980 are estimated below for industry, municipalities and recreational development within the Basin. Also shown are the program costs of water quality surveillance during this period.

Water Quality Control
1970-1980

Feature	Investment Costs ($1000)	Average Annual Costs: Interest & Amortization ($1000)	Average Annual Costs: O&M ($1000)	Average Annual Costs: Total ($1000)	Average Annual: Benefits[2] ($1000)
Monitoring, Evaluation & Control Program	490[1]				
Industrial Wastes					
Treatment	2,400	126	26	152	152
Municipal Wastes					
Treatment	800				
Sewers	1,200				
Subtotal	$2,000	$99	$22	$121	$121
Recreation Wastes					
Treatment	480	42	5	47	47
Total	$5,370	$267	$53	$320	$320

[1] Cumulative annual program costs for the period.
[2] Average annual benefits assumed to be at least equal to average annual costs.

A review of minimum flows of record and anticipated diversions revealed that in 1980, the 240 cfs required for assimilation of residual wasteloading, after secondary treatment would be available, in the Skagit River, at Mount Vernon.

1980-2000 and 2000-2020–During these periods expansion by industry, new developments and growth of urban and recreation areas would require that new sewer interception systems be installed and treatment facilities enlarged and/or constructed. Summarized below are estimated investment costs for water quality control for each period.

The minimum 2020 flows required to meet water quality standards in the Skagit River at Mount Vernon is 650 cfs. A review of minimum flow records, anticipated consumption of Basin waters in the year 2020, including surface diversions for irrigation and municipal and industrial water supply, indicates that a 7-day minimum flow of at least 3,500 cfs would be available in the Skagit River to assimilate projected residual wasteloadings for 29 out of 30 years.

Water Quality Control
1980-2020

Feature	Investment Costs ($1000) 1980-2000	2000-2020
Monitoring, Evaluation & Control Program	360[1]	420[1]
Industrial Wastes		
Treatment	2,650	4,200
Municipal Wastes		
Treatment	1,800	480
Sewers	2,700	2,220
Subtotal	$4,500	$3,700
Recreational Wastes		
Treatment	900	1,000
Total	$8,410	$9,320

[1] Cumulative annual program costs for the period.

Navigation

Waterborne commerce of general cargo, dry bulk and petroleum is expected to increase significantly in the Skagit-Samish Basins. Large tankers would continue to serve the two oil refineries located in the Basins with greater quantities of bulk petroleum anticipated in the future, commensurate with growing needs of the Area for refined petroleum products. As a result of the large tankers, dredging of Guemes channel would be required to accommodate the deeper draft bulk petroleum vessels. Deepening of the Swinomish channel in Padilla Bay would be required to serve a terminal and industrial area located in either side of the channel. The city of Anacortes has initiated development of an industrial park in Fidalgo Bay with a channel required to service development which would be adequate to serve progressively larger barges and freighters as industry develops and expands. Dredged materials from the various channel projects in Padilla and Fidalgo Bays can be used as part of the land reclamation for development of industrial sites.

Navigation development as provided for in the Comprehensive Plan is discussed by the following time periods:

1970-1980–Deepening of the Guemes channel is planned during this period to provide for the deeper draft bulk petroleum vessels which serve refineries at Anacortes and at Marsh Point located between Fidalgo and Padilla Bays. A deep draft channel is proposed to service freighters and large barges in Fidalgo Bay at a development proposed by the city of Anacortes. Further development of existing and planned new areas of the Port of Anacortes would occur before 1980 including the city of Anacortes industrial park as well as expansion of refinery facilities at Marsh Point. The planned channel improvements are:

Navigation Improvements
1970-1980

Channel	Length (Miles)	Depth (Feet)	Investment Costs ($1000)	Average Annual Costs: Interest & Amortization ($1000)	Average Annual Costs: O&M ($1000)	Average Annual Costs: Total ($1000)	Average Annual Benefits ($1000)
Guemes	4.6	54	612	29	2	31	51
Fidalgo	1.1	32	853	40	10	50	54
Total	5.7		$1,465	$69	$12	$81	$105

The dramatic need for marine-oriented recreational facilities is evidenced by the demand for 1,845 additional wet moorages by 1980 for the Skagit-Samish Basins. An addition at the Anacortes small boat basin and development of a small boat harbor at LaConner at Indian Bay are planned to satisfy wet moorage needs of both the Skagit-Samish Basins and the spillover from unsatisfied needs from the Stillaguamish Basin. A total of 850 wet moorages would be provided at these small public boat harbor developments. The difference between the 850 wet moorages provided by public investment and the total need of 1,845 is assumed for purposes of this study to be met by further private development. The investment costs and average annual costs and benefits of the small public boat harbor projects planned for contruction by 1980 would be:

Small Boat Harbor Projects
1970-1980

Location	Wet Moorages	Invest. Costs ($1000)	Average Annual[1] Costs ($1000)	Average Annual[1] Benefits ($1000)
Anacortes addition	600	1,212	77	112
LaConner-Indian Bay	250	502	32	47
Total	850	$1,714	$109	$159

[1] General navigation facilities costs and benefits only, based on 50-year economic life amortized at a 4-5/8% interest rate. Total pleasure boat facilities costs and benefits included with Recreation.

1980-2000—During this period sites on Padilla Bay on either side of the existing Swinomish River channel would be developed for terminal and water transport-oriented industrial use. Further development of other existing sites would also be expected to occur commensurate with a growth in waterborne commerce and petroleum refining. The channel improvements for this period are shown below:

Navigation Improvements
1980-2000

Channel	Channel Dimensions: Length (Miles)	Channel Dimensions: Depth (Feet)	Invest. Costs ($1000)
Guemes	4.7	78	4,052
Fidalgo Bay	1.2	40	942
Padilla Bay	3.5	46	4,423
Total	9.4		$9,417

Public small boat harbor projects tentatively scheduled in the Plan for construction prior to 2000 are:

Small Boat Harbor Projects
1980-2000

Location	Wet Moorages	Invest. Costs ($1000)
Fidalgo Island-West	1,650	3,329
LaConner-Indian Bay	250	502
Total	1,900	$3,831

2000-2020–During this period full development of terminal and industrial water transport-oriented industrial sites shown in Appendix VIII, Navigation, is projected including Padilla Bay. Further deepening of navigation channels to provide for projected increases in drafts of freighters and bulk cargo vessels would be undertaken in Padilla Bay and Fidalgo Bay. These planned navigation improvements would be:

Navigation Improvements
2000-2020

Channel	Channel Dimensions Length (Miles)	Depth (Feet)	Invest. Costs ($1000)
Fidalgo Bay	1.2	46	608
Padilla Bay	3.6	54	2,381
Total	4.8		$2,989

Significant development of public wet moorages is planned during this latter period to satisfy pleasure boating needs of the public. The projects tentatively scheduled for future development are shown in the tabulation below:

Small Boat Harbor Projects
2000-2020

Location	Wet Moorages	Invest. Costs ($1000)
Padilla Bay-Williams Point	1,120	1,285
Guemes Island Southwest	1,100	1,260
Fidalgo Island West	1,120	1,285
Total	3,340	$3,830

Power

Under the present operations of the existing hydroelectric plants there are peaks which cause fishery and other problems along the Skagit River due to fluctuations in river flows. Greater peaking operation is anticipated in the future which could aggrevate these problems. Increasing peak power demands could dictate increasing the capacity of Seattle's Skagit River hydroelectric plants to help meet the Area's short-term and daily peaks. Power peaking releases from these plants, detrimental to fish now, could become increasingly more so in the future. Reregulation of these flows, compatible with downstream fish use, is viewed as important to future fish production. A reregulation project at the Copper Creek site on the Skagit River which would produce additional hydroelectric energy has marginal economic feasibility at this time. As hydropower peaking becomes more important to the Puget Sound Area, reregulation benefits would be expected to justify the Copper Creek project after 1980. The site is upstream of the limits of the Wild and Scenic Rivers study and is therefore included for further consideration.

The raising of Ross Dam is being planned by Seattle City Light Department to increase power generation. This project is considered economically feasible and may be undertaken before 1980. Raising of Ross Dam would provide a pool which would back water into Canada. The current maximum reservoir is just short of the Canadian Border. With Ross Dam raised, additional generating units would be installed at Gorge and Diablo Dams to increase power production at these facilities.

The Lower Sauk River storage site is the only remaining prospect for obtaining additional hydroelectric power production from multiple-purpose storage at an economical cost. Other purposes could include low flow augmentation for fish, recreation, and water quality improvement through trapping of glacial sediments. However, the Sauk project, included as an element under Alternative A, provides for hydroelectric power and flood control only. The project is only marginally feasible at this time and is therefore included for the 1980-2000 development period, when increased power demand and growth in flood damages would probably make the project a better economic undertaking.

One or more nuclear base load electric generating plants may be constructed in the Skagit-Samish Basins prior to 2020 to serve Area needs. Several sites within the Skagit-Samish Basins are being considered for construction of nuclear power plants. These include Samish and Kiket Islands. If plants are contructed they would probably utilize sea water for cooling. However, further studies must be conducted in the Puget Sound Area before specific site selections can be made.

Pumped-storage hydroelectric peaking plants would also undoubtedly be constructed in the Skagit-Samish Basins in the period 1980-2000. More than 40 sites have been identified by preliminary studies as potential for development. Fossil-fuel peaking plants also may be constructed in the Basins in the long-range period.

Flood Control

Industrial and urban lands within the Basins have been recommended for 100-year level of flood protection, agricultural lands at least 25-year level of protection and lands along the flood plain to be used for parks, golf courses and general recreation requiring a level of protection of 10-15 years. Implementation of the Comprehensive Plan would reduce flood damages in the Skagit-Samish Basins. Flood protection objectives would generally be met under Alternative A.

Flood plain management measures such as floodproofing, flood plain zoning, or other positive means of land use control would be implemented. Sufficient lands are considered to be available within the Skagit-Samish Basins to preclude the necessity of intensive development in unprotected flood plains. However, without flood plain zoning structural measures such as storage projects may be needed beyond those provided in the Plan. Uncontrolled encroachments on the flood plain by residential and industrial developments would require expensive structural flood control measures to protect these high value investments.

That portion of the Comprehensive Plan dealing with flood control is discussed below by time periods.

1970-1980—During this period 100,000 acre-feet of flood control storage in the existing reservoir on Baker River at the Upper Baker project would be purchased. The lost power producing capability would be compensated at an estimated cost of $133,000 annually. Also requiring early action would be construction of the Avon Baypass. The size of the Bypass under Alternative A would be for a flow of 60,000 cfs and would cost $28,900,000. The existing levees and channel downstream from Burlington would be improved before 1980 as well as the levees along the left bank of the Skagit River at Nookachamps Creek, between Mount Vernon and Sedro Woolley. The levees along the Skagit River at Nookachamps Creek would cost an estimated $2,500,000 to construct. These features including the Upper Baker River storage and the existing 120,000 acre-feet of flood control storage in Ross Reservoir would be designed to provide 50-year flood protection for Burlington and Mount Vernon and 25-year protection for the large farming area in the vicinity and downstream of Burlington and Mount Vernon for the Nookachamps Creek area. The Nookachamps Creek levees would be designed to be overtopped before levees at Burlington and Mount Vernon were overtopped to assure that the valley storage at Nookachamps Creek remains available for flood protection storage for the major urban areas of the Basins during large and infrequent floods. The levee and channel improvements downstream from Burlington would amount to $7,000,000 resulting in a channel capacity downstream from the Avon Bypass intake of 120,000 cfs.

Flood plain management measures including a warning system and land use zoning would be important tools for mitigating future flood damages. Flood plain zoning costs include $31,000 for local preparation of a flood plain zoning plan and $8,400 annually for implementation of the plan. These expenditures would be justified by the reduction of about $480,000 in average annual flood damages.

The tabulation below summarizes the early action flood control programs and projects for the Skagit-Samish Basins under Alternative A.

Flood Control Element	Effective Flood Control Storage (Ac.Ft.)	River Mile	Height Of Dam (cfs)	Design Capacity (cfs)	Invest. Costs ($1000)	Average Annual Costs: Interest & Amort. ($1000)	Average Annual Costs: O&M ($1000)	Average Annual Costs: Total ($1000)	Average Annual Benefits ($1000)
Flood Control Storage Projects									
Upper Baker	100,000	9.0	330					133	300
Channel and Levee Construction									
Avon Bypass-Alt. A				60,000	28,300	1,434	66	1,500	2,147
Levee and channel improvement from Burlington-Mount Vernon area downstream to mouth of both Forks				120,000	7,000	344	10	354	853
Levee Construction									
Levees at Nookachamps Creek area				135,000	2,500	123	6	129	150
Subtotal					$37,800	$1,901	$82	$2,116	$3,450
Flood Plain Management					115				480
Total-Alt. A					$37,915				

1980-2000—Under Alternative A the Lower Sauk project would be constructed during this period at a total investment cost of $128,000,000 with $60,000,000 allocated to flood control. This project in conjunction with the measures undertaken before 1980 would provide 100-year flood protection downstream from Sedro Woolley and 15 to 25-year protection for agricultural areas upstream. Levees would be constructed at Hamilton (3 miles) and Sedro Woolley (4 miles) at a cost of $2,800,000 and $3,000,000, respectively, providing 100-year level of flood protection for these communities. Flood plain management costs during this period would amount to $168,000.

2000-2020—Flood plain management would be continued during this period at a cost of $168,000. No further structural measures are anticipated.

Watershed Management

Watershed management measures for the Skagit-Samish Basins are described in Appendix XIV, Watershed Management, and summarized in the Puget Sound Area section of this Appendix. These measures, including new installations, upgrading of existing facilities and improvements and more intense application of practices, would be required for flood prevention, water management, and watershed rehabilitation and protection. While the entire water-related land acreage requires a variety of such measures, the intensity of application of the treatment measures, and the relative composition of such measures, vary with the capability of the land and the kind and intensity of use. Much advantage is gained by selection of suitable land for specific uses. The results would be increased production, other economic benefits, and enhanced environmental values. The program includes a continuing investment of both the public and private sectors to protect and develop the water and related land resources within the Basins.

Federal and State land administrative agencies are responsible for the installation of the measures on lands assigned to their management, while individual initiative of the owner is required for installation of practices on lands in private ownership. Various Federal agencies and the State have programs of technical and financial assistance for individuals, local organizations, and subdivisions of government, including the Whatcom, Skagit and Snohomish County Soil and Water Conservation Districts.

The Plan includes projects primarily for flood and sediment damage reduction, the management of agricultural water, other water management, and watershed treatment measures, which have been coordinated to the extent feasible with flood control and other projects of the Federal Government and the State. Other Federal and State projects furnish incentives for installation of urban water management and similar improvements, including flood control measures.

1970-1980—Several projects are recommended for initiation prior to 1980 in order to remedy existing flood water damage and provide water management for various purposes. Following are descriptions of projects planned for early action:

Gages Slough Watershed is that area tributary to the north side of the Skagit River and includes the cities of Burlington and Sedro Woolley, both of which lie within the flood plain. The major portion of the watershed is flood plain of the Skagit River with only a small area of hill land which is located north of Sedro Woolley. The forest area is largely confined to a small area on hills and Hart Island Slough. Woodlands on the high portions consist of mixed stands of Douglas-fir and red alder, in the lower lands, red alder and cottonwood. The upland areas provide excellent homesites and the development should be planned to enhance the landscape and preserve water resource values.

The project is designed for flood prevention on agricultural and urban areas, and drainage of agricultural lands. The area includes 14,419 acres of which 7,100 acres are cropland, 1,362 acres are forest, 4,841 acres rural non-farm and 1,116 acres miscellaneous uses.

The works of improvement would consist of approximately 17 miles of channel improvement and stabilization and one outlet structure which would contain floodgates and pumps.

Installation cost is estimated to be $1,107,000 of which the Federal share is $705,000, and the local share is $402,000. The project's average annual benefits from damage reduction and drainage of $244,000 are compared with average annual costs of $61,000 including $9,000 for O&M. To achieve benefits made possible by the structural works and other management during a 15-year period, local interests would install necessary land treatment measures for erosion control and flood management costing approximately $555,000, drainage measures expected to cost $1,630,000 and forest protection and management practices costing $29,000, for a total of $2,209,000. The total cost of installing the structural measures and the land treatment measures is $3,316,000.

South Mount Vernon Watershed is an area of about 50 square miles on the south and east sides of and tributary to the Skagit River. It includes the city of Mount Vernon and most of the flood plain south of the city. About 30 square miles of hill land east of this flood plain are included in the watershed. A contour flood channel located at the base of these hills conveys floodwater from the uplands to an outlet into the South Fork of the Skagit River. This channel makes possible the farming of the low-lying flood plain area. The area is cultivated annually and

produces high value seed and vegetable crops.

About 60 percent of the watershed is forest covered. Forests occur mainly on the upland where there is nearly a solid stand of Douglas-fir. Following logging, many cutovers reverted to mixed Douglas-fir and red alder stands. On the higher slopes, the Douglas-fir predominates in thrifty young stands which rapidly reach log size. Much area is held for commercial timber but due to easy access and some attractive lakes, there is a great demand to acquire tracts for forest retreats. There are areas of steep ground where timber harvest, roads, or other development needs land treatment or special planning.

The project is designed for flood prevention of agricultural and urban areas, and drainage of agricultural lands. The area contains 32,132 acres of which 11,500 acres are cropland, 14,881 acres are forest, 4,231 acres rural non-farm and urban, and 1,520 acres miscellaneous uses.

The works of improvement would consist of 22 miles of improved and stabilized channel and four outlet structures with floodgates and pumps. Approximately one-half mile of protective embankment would be installed at the south side of the flood plain area.

Installation cost is estimated to be $1,434,000, of which the Federal share is $1,028,000, and the local share is $406,000. The project's average annual benefits from damage reduction and drainage of $322,000 are compared with average annual costs of $81,000 including $14,000 for O&M. To achieve benefits made possible by the structural works and other management during a 15-year period, local interests would install necessary land treatment measures for erosion control and flood management at a cost of approximately $890,000; drainage measures at $2,207,000; and forest protection and management practices at $318,000; for a total of $3,415,000. The total cost of installing the structural measures and the land treatment measures is $4,849,000.

The Samish River flows into Samish Bay and Leary Slough, a subwatershed outlet to Padilla Bay through the north edge of the Skagit River flood plain. The Samish River originates near the South Fork of the Nooksack River. This stream has a very narrow flood plain and flows for much of its length between steep and rugged mountains. Its tributary streams, except for Friday Creek, are short and steep.

About 85 percent of the watershed is forest land. On the lower slopes there is a mixed stand of Douglas-fir and red alder, and above this is a belt of Douglas-fir. At the higher elevations, on the east side, western hemlock is the predominating species and on the crest of the ridges the forest stand consists of true firs. All the area has productive timberland that has been logged at various periods. Much of the area would continue to be managed for harvesting of wood products, depending on size and type of ownership, accessibility and distance from more developed areas.

The project is designed for flood prevention of agricultural and urban areas, and drainage of agricultural lands. The area contains 63,716 acres, of which 26,287 acres are cropland, 31,454 acres are forest, 2,852 acres rural non-farm and urban, and 3,123 acres is used for miscellaneous purposes.

The works of improvement would consist of 65 miles of improved and stabilized channel and five outlet structures consisting of floodgates and pumps.

Installation cost is estimated to be $4,862,000, of which the Federal share is $3,432,000, and the local share is $1,430,000. The average annual benefits from damage reduction and drainage of $755,000 compare with average annual costs of $272,000 including $45,000 for O&M. To achieve benefits made possible by the structural works and other management during a 15-year period, local interests would install necessary land treatment measures for erosion control and flood management at a cost of approximately $2,035,000; drainage measures at $5,422,000; and forest protection and management practices at $672,000, for a total of $8,128,000. The total estimated cost of installing the structural measures and the land treatment measures is $12,990,000.

Skagit Flats Watershed is the delta of the Skagit River, lying on the north and west sides of the river and includes Fir Island. The watershed is on nearly level land except for a few points and ridges that appear almost as islands in the level plain. The level areas are for the most part farmed in annual crops. This is the largest area of excellent high-producing agricultural soil in the Puget Sound Area. Almost all of the agricultural area is below 10 feet mean sea level elevation. Flood control and drainage problems are severe and many flood control and diking districts are located in the watershed.

The project is designed for flood prevention of agricultural and urban areas, and drainage of agricultural lands. The watershed contains 41,148 acres, of which 28,487 acres are cropland, 4,834 acres are

forest, 3,828 acres rural non-farm and urban, and 3,999 acres miscellaneous uses.

The works of improvement would consist of 43 miles of improved and stabilized channel, five outlet structures consisting of floodgates and pumps, and five miles of new and reconstructed dikes.

Installation cost is estimated to be $3,234,000, of which the Federal share is $2,060,000, and the local share is $1,174,000. The project's average annual benefits from damage reduction and drainage of $921,000 are compared with average annual cost of $180,000 including $29,000 for O&M. To achieve benefits made possible by the structural works and other management during a 15-year period, local interests would install necessary land treatment measures for erosion control and flood management at a cost of approximately $2,205,000, drainage measures at $6,454,000, and forest protection and management practices at $103,000 for a total of $8,762,000. The total cost of installing the structural measures and land treatment measures is estimated to be $11,996,000.

The following programs include the complementary features to the projects discussed above and other non-farm and urban on-site practices required in the Skagit-Samish Basins.

Watershed Management Practices
1970-1980

Program	Area (acres)	Costs ($1000)
Technical assistance		
& management	1,873,658	
Federal, regular		31,750
Federal, accelerated		245
Subtotal		$31,995
Installation of practices		
(non-Federal)		
State and corporate		
management		9,585
Land treatment	470,401	9,118
Water management		
Agricultural	33,800	14,063
Urban	16,885	22,795
Subtotal		$55,561
Total		$87,556

1980-2000—The programs and projects scheduled for this period are shown below, with estimated installation costs:

Watershed Management Practices
1980-2000

Program	Area (acres)	Costs ($1000)
Technical assistance		
& management	1,873,658	
Federal, regular		42,147
Federal, accelerated		245
Subtotal		$42,392
Installation of practices		
(non-Federal)		
State and corporate		
management		12,779
Land treatment	470,401	12,157
Water management		
Agricultural	27,235	17,606
Urban	10,587	14,292
Subtotal		$56,834
Total		$99,226

Project	Area (acres)	Structural Measures Installation Cost ($1000)
North Skagit tributaries	67,186	1,200
South Skagit tributaries	115,039	350
Fidalgo Island group	39,289	300
Total	221,514	$1,850

Non-Federal costs include present costs of on-going programs of development with redirection and acceleration to meet needs. Total costs are shown.

2000-2020—The programs and projects recommended for implementation during this period are:

Watershed Management Practice
2000-2020

Program	Area (acres)	Costs ($1000)
Technical assistance		
& management	1,873,658	
Federal, regular		36,596
Federal, accelerated		409
Subtotal		$ 37,005
Installation of practices		
(non-Federal)		
State and corporate		
management		12,779
Land treatment	470,401	12,157
Water management		
Agricultural	49,023	31,955
Urban	11,424	15,422
Subtotal		$ 72,313
Total		$109,318

Project	Area (acres)	Structural Measures Installation Cost ($1000)
Upper Skagit River	702,355	760
Baker River	182,231	100
Cascade River	117,475	100
Suiattle River	221,575	100
Sauk River	244,446	400
Total	1,468,082	$1,460

Recreation

There is a great potential for development of recreation opportunities along the salt water shoreline of the Skagit-Samish Basins. The land adjacent to Skagit, Padilla and Samish Basins suitable for recreation sites is limited due to the extensive tidal flats and marshy areas. However the shorelines of Similk Bay and Fidalgo Island are favorable for recreation development. The many miles of rivers and streams and lake shoreline also provide opportunities to meet recreation needs.

The National Forest and National Park lands in eastern one-half of the Skagit Basin and the State lands in the central portion provide a large amount of public lands for recreation use. Some of the more than 88,000 acres of undeveloped class III recreation lands owned by the State Department of Natural Resources are suitable for recreation site development, especially those areas adjacent to bodies of water. There are undeveloped State-owned lands scattered throughout the central and western portion but with the exception of shore and tide lands only a few have frontages on major rivers or lakes. Satisfaction of recreation demands depends upon the provision of additional recreation lands by public and private interests in the central and western portions of the Skagit Basin. As Anacortes and other urban areas expand efforts need to be undertaken to provide for adequate recreation areas and open space within and near urban areas.

The broad recreation goal is to promote well-planned development and protection of existing resources and to provide an opportunity for the satisfaction of present and future outdoor recreation needs of the population. Based on Federal ownership of land, plans and programs of recreation suppliers, and the expected population concentration as well as outdoor recreation needs, the assumption is made that the Federal agencies would provide 30 percent of the required water-related recreation opportunities, while the State, county and local agencies, and private interests would supply 20, 30 and 20 percent, respectively.

Additional facilities and acquisition and development of land and water areas are required in order to satisfy the project recreation needs. The specific land and water area requirements are stated in the following tabulation:

Recreation Land and Water Requirements
1960-2020

Activity	Unit	1960 Land	1960 Water	1980 Land	1980 Water	2000 Land	2000 Water	2020 Land	2020 Water
Swimming									
Beach Area	Acres	0	0	6	1	26	3	56	10
Pools	Sq.Ft.	32,000	16,000	67,000	34,000	134,000	67,000	255,000	128,000
Boating, Sailing & Water Skiing	Acres	15	0	65	0		0	370	18,655
Camping	Acres	346	--	916	--	2,016	--	3,916	--
Picnicking	Acres	135	--	275	--	475	--	775	--
Hiking	Miles	0	--	0	--	0	--	81	--

The recreation development as discussed in following paragraphs are intended to be compatible with the Washington State Outdoor Recreation and Open Space Plan.

1970-1980—The Avon Bypass would be developed as a completely controlled, 7-mile long lake with excellent access. The banks formed by dredged spoil material from the channel would be 50 to 100 feet wide. The top of the channel would be about 400 feet. Studies made in conjunction with the Avon Bypass project have indicated its potential for multiple-purpose recreation including fishing, hunting and general recreation such as boating, swimming, camping and picnicking. The inclusion of recreation facilities as part of the Bypass project would be a local and State responsibility. The investment costs estimated for in the water-related recreation development are assumed to cover this addition to the project. Throughout the Skagit-Samish Basins existing improvements would be made on publicly-administered developed recreation areas including camp and picnic units. Over sixty recreation sites are planned for improvement or development before 1980.

Designation of a network of scenic roads to provide travel links between recreation attractions which would enhance driving for pleasure and sightseeing opportunities in the Basins also is planned for early action. These roads would be included within a State-wide system of scenic roads. Additional sites along the marine shoreline would be investigated for suitability for acquisition and development as salt water parks. The natural flood plain along the Skagit River would be preserved consistent with the portions of the Comprehensive Plan discussed under Flood Control. Land use zoning as one element of flood plain management is viewed as essential to insure that lands would be retained for this purpose.

Under Alternative A (with Sauk River Project), a State system is suggested to protect the important recreation rivers or river segments in a free flowing state for public use. The Cascade River from its mouth to the junction of its north and south forks, the South Fork of the Cascade River from its mouth to the Glacier Peak Wilderness area, the Suiattle River from river mile 4 to Glacier Peak Wilderness and the Sauk River from Darrington to its junction with the Elliott Creek in the North Fork of the Sauk from the mouth to Glacier Peak Wilderness area would be studied to determine if these streams or portions thereof would qualify for protection.

Although the existing waters in the Skagit-Samish Basins would satisfy water-based recreation demand to nearly the year 2020, the lake behind the Sauk River storage project could provide water-related recreational opportunities after 1980. For purposes of this study no recreation development has been planned for the Sauk River project.

1980-2000—During this period further development of existing public lands is anticipated as well as some private land with expenditures for improvements and developments estimated at $26,800,000 and $15,900,000 for land acquisition including buffer zones with nearly 80 recreation sites planned for expansion or new development.

2000-2020—During this latter period approximately 90 recreation sites would be expanded or developed throughout the Skagit-Samish Basins. A retention of public-owned properties held at present and the acquisition of additional lands required to satisfy recreational needs are assumed. With the proper public land management and the use of waterfront access leases, large scale of acquisition of private lands is not foreseen as being necessary to meet future needs. The program for recreation development combined with complementary fish and wildlife features would meet the future recreation needs of the Skagit-Samish Basins. Total recreation development costs during this period are estimated at $43,900,000 with land acquisition including buffer zones estimated $27,400,000.

Thirty percent of the water-related recreation demand would be satisfied on lakes and reservoirs, 35 percent on rivers and streams, 10 percent on swimming pools and 25 percent on salt water areas.

Investments for recreation facilities other than those discussed previously are tabulated below for the various water-related improvements:

Outdoor Recreation Improvements
1970 to 1980

		Average Annual			
		Cost			
Feature	Investment Costs ($1000)	Interest & Amortization ($1000)	Operation & Maintenance ($1000)	Total ($1000)	Benefits ($1000)
Campgrounds	12,824				
Picnic Areas	1,085				
Beaches	84				
Swimming Pools	850				
Boating Facilities	3,666				
Planning & Design	4,627				
Land Acquisition	12,678				
Total	$35,814	$1,870	$685	$2,555	$3,600

Fish and Wildlife

The Skagit-Samish Basins offer numerous opportunities for projects and programs that, if implemented would maintain and increase fish and shellfish production. The Basins contain a very important anadromous and resident fishery together with a resident wildlife population of deer and other big game animals. The limiting factors of primarily salmon production include damage to spawning beds resulting from floods and from gravel compaction by glacial sediment; loss of fish stranded during floods and during power peaking operations, and egg damage and fry loss due to low flows. There is a requirement for low flow augmentation and control of floods to meet anadromous fish production needs prior to 1980. Flood storage on the Baker River would provide only a part of the total flood control needed. Consequently, the enlargement of existing hatcheries was added to the early action program and construction of fish passage facilities at the falls on the North Fork of the Cascade River was advanced from after 1980 to before 1980 to satisfy the salmon production needs projected for 1980.

The Sauk River storage project would result in the inundation of anadromous fish spawning areas as well as blocking upstream migration of these fish. In addition, valley lands used for wildlife habitat would be lost. However, fish passage facilities would be included as a project feature and also other mitigation measures to provide for equivalent fish production. Wildlife mitigation would be provided for. A resident game fishery could be developed in the Sauk reservoir to offset the loss in resident stream fishery with adequate game fish hatching and rearing facilities provided for seasonal stocking of the reservoir. Extensive studies would be made to measure the overall effects on fish and wildlife and to establish the type and extent of mitigation measures to be included in the project.

That portion of the Comprehensive Plan dealing with fish and wildlife is discussed by time periods as follows:

1970-1980—Important measures planned for the enhancement and preservation of fish include the expansion of two existing salmon hatcheries in the Skagit Basin at an estimated cost of $660,000. The expanded hatcheries would produce an additional 24,200 fish for commercial harvests and about 4,000 fish for sport harvests.

A permanent fish-passage facility would be provided at a partial barrier on the Cascade River at an estimated cost of $30,000 and would increase commercial and sport harvest by 3,800 and 500 salmon, respectively. A fish passage facility also would be installed on the North Fork of the Cascade River at a cost of $25,000 and result in an increase in harvest of 6,600 salmon.

Access at eight small lakes within the Skagit-Samish Basins is planned along with picnicking, parking and other facilities at an estimated investment cost of $128,000 and would result in an average of 59,400 user-days of recreation benefits. Fishing piers are planned at Samish Lake at an estimated cost of $65,000 which would provide about 5,000 user-days of recreation activity annually. A trout hatchery to stock water at lakes is planned for construction at a cost of $850,000 as well as development of new fish toxicants and lake fertilizers to improve the productivity of the Basins waters at a total cost of $40,000. These measures would produce an estimated average annual 142,500 user-days as sport fishing activity. Acquisition of land or the obtaining of long-term leases for streambank access on 75 miles of the Basins major tributaries is called for at an estimated cost of $1,396,000. Cross-sectional stream surveys would determine the most beneficial flows for spawning, incubation, rearing and fish. Techniques would be developed to better evaluate such flows. This would be an Area-wide study with costs indicated in the Puget Sound Area section of this Appendix. A second trout hatchery in the Basins to meet growing stream sport-fishery needs is included for construction at an estimated cost of $2,000,000. This would provide an average of 103,000 annual user-days of benefits.

Before 1980, programs would provide for the enhancement of marine fish including the creation of additional production habitat through selective placement of rock jetties or submerged scrap automobiles. Shellfish production and harvest would benefit from the construction of beach breakwaters where strong currents now limit the production. Studies and implementation of techniques to eliminate or control

natural predators and the alteration of environment promote and increase natural production are planned. Shellfish and marine fish features have not been evaluated in terms of costs of benefits but are included in the Comprehensive Plan for further study by the State Fish and Game agencies.

Wildlife measures included for early action are the acquisition and development of 12,000 acres of waterfowl habitat, acquisition and development of 500 acres of band-tailed pigeon area in the Samish Basin and the acquisition and development of salt water access for waterfowl hunting. These measures are estimated to cost $6,185,000 and produce an estimated 104,500 user-days of hunting activity each year. In addition to an existing game-bird farm to produce approximately 5,000 additional birds is called for at an estimated investment cost of $50,000 which would provide 6,800 user-days of increased hunting annually.

Implementation of cooperative programs with private land owners to insure habitat retention hunting is planned together with development and continued wildlife population studies. An educational program is included to stress renewable aspects of the wildlife resource and value of proper utilization of the resource. The cost of these measures is estimated at about $55,000 over the 10-year period. New methods would be developed for wildlife population analysis, habitat improvement techniques and compatible forest-wildlife management practices at an estimated capital cost of $35,000.

The project and programs for fish and wildlife preservation enhancement are tabulated below:

Projects

a. Enlargement of existing fish hatcheries.

b. Construction of fish passage facilities at Cascade Falls.

c. Acquisition and development of access to eight lakes.

d. Construction of fishing piers at Samish Lake.

e. Construction of two trout hatcheries.

f. Construction of one rearing pond for summer steelhead.

g. Construction of one rearing pond for winter steelhead.

h. Acquisition of 75 miles of streambank access.

i. Acquisition and development of six saltwater access areas.

j. Acquisition and development of 12,000 acres of waterfowl habitat.

k. Acquisition of access to 500 acres of band-tailed pigeon area.

l. Enlargement of game farm to produce 5,000 additional birds.

m. Construction of fish passage facilities on North Fork Cascade River.

Programs

a. Development of fish disease control program.

b. Development of new fish toxicants.

c. Development of lake fertilization technique.

d. Development of cooperative programs with private land owners to insure habitat retention and hunter access.

e. Development of compatible forest-wildlife management techniques.

f. Development of educational programs regarding value of wildlife.

g. Perform cross-sectional studies of streams for optimum and minimum low flow determination.

h. Locate, survey, and mark boundaries of all State-owned second class tidelands in the Basin. Take steps to reserve all such lands to public use except as required for specific circumstances.

i. Perform an inventory of shellfish stocks and recreational use of tidelands.

1980-2000—Projects planned for increased salmon production include habitat improvement on 38 miles of stream at an estimated cost of $154,000. Stream clearance on 38 miles of stream would cost $14,800 to produce 47,300 commercial fish annually and 7,300 sport fish harvest annually. Two salmon hatcheries would be constructed to increase chinook salmon harvest by 87,500 fish annually. Two spawning channels would be constructed at an estimated cost of $1,400,000 and produce 200,000 fish for commercial and sport harvest annually. One-hundred and twenty-thousand pink salmon and 120,000 sockeye salmon would be produced by the spawning channels. A total investment of $18,608,800 is estimated for the game-fish and wildlife programs and projects to be implemented during this period as:

Fish and Wildlife
Project and Program Costs
1970-1980

Feature	Investment Costs ($1000)	Interest & Amortization ($1000)	O&M ($1000)	Total ($1000)	Benefits ($1000)
Projects	11,799	62	799	1,420	1,910
Programs	253[1]				497[2]
Total	$12,052				$ 2,407

[1] Cumulative program costs for the period.

[2] Some of program benefits included in with project benefits.

Fish and Wildlife
Projects and Programs
1980-2000

Projects	Investment Costs
Artificial salmon propagation facilities	500,000
Improvement of fish habitat on 38 miles of stream	154,000
Continuation of stream channel clearance	14,800
Construction of two salmon hatcheries	2,040,000
Construction of 2 miles of salmon spawning channel	1,400,000
Other game fish and wildlife projects including access and parking facilities to all State-owned beaches	14,800,000
Total	$18,408,800
Programs	
Continuation of fish and wildlife programs including improvement of public beaches for clam culture	$ 200,000

2000-2020—During this period six additional hatcheries are planned for construction within the Skagit-Samish Basins to produce nearly 36,000 chinook salmon and 153,000 coho salmon at a cost of $6,120,000. One-hundred and thirty acres of rearing facilities to provide nearly 40,000 chinook salmon and 110,500 silver salmon also are included at a cost of $715,000. An increase of 240,000 pink salmon would result from two miles of spawning channel at an initial investment cost of $1,400,000. A total investment cost of $23,235,000 is estimated for game-fish and wildlife programs and measures during this period. The fish and wildlife projects scheduled for implementation prior to 2020 are:

Fish and Wildlife
Projects and Programs
2000-2020

Projects	Investment Costs
Construction of six salmon hatcheries or equivalent	6,120,000
Development of 130 acres of rearing facilities	715,000
Development of 2 miles of spawning channel	1,400,000
Other game fish and wildlife projects	$14,800,000
Total	$23,035,000
Programs	
Continuation of fish and wildlife programs	$ 200,000

COST-BENEFIT SUMMARY ALTERNATIVE A

The investment costs by resource feature are shown in Tables 4-20 and 4-21 for the Skagit-Samish Basins with the costs distributed between Federal, State, local, and private interests. Average annual costs and benefits also are shown for projects recommended for implementation prior to 1980. The investment costs include cumulative annual program costs for each of the three planning periods as shown in Table 4-20 and capital project costs as shown in Table 4-21. Interest and amortization costs are based on a 100-year economic life with appropriate allowances made for major replacements. An interest rate of 4 5/8 percent was used in the economic analysis. All measures proposed for early action are justified on the basis of tangible benefits. Benefits for M&I water supply and water quality improvement were assumed equal to annual charges.

Investment costs were allocated to the various interests on the basis of available information including the technical appendices, multiple-project studies, and experience at similar projects.

TABLE 4-20. Program investment costs,[1] Alternative A, Skagit-Samish Basins ($1000)

Feature	Private	Government			Total
		Local	State	Federal	
			1970-1980		
Water Quality Control	83	83	226	98	490
Flood Control		90	17	8	115
Watershed Management	42,685	7,988	4,888	31,995	87,556
Fish & Wildife			253		253
Total	$ 42,768	$8,161	$5,384	$ 32,101	$ 88,414
			1980-2000		
Water Quality Control	64	64	164	68	360
Flood Control		117	34	17	168
Watershed Management	43,765	6,554	6,517	42,390	99,226
Fish & Wildife			200		200
Sub-Total	$43,829	$6,735	$6,915	$42,475	$ 99,954
			2000-2020		
Water Quality Control	70	70	196	84	420
Flood Control		117	34	17	168
Watershed Management	58.554	7.244	6,517	37.003	109,318
Fish & Wildlife			200		200
Sub-Total	$ 58,624	$ 7,431	$ 6,947	$ 37,104	$ 110,106
Total	$145,221	$22,327	$19,246	$111,680	$298,474

[1] Cumulative annual program costs over the period.

TABLE 4-21. Project investment costs[1] and cost-benefit summary, Alternative A, Skagit-Samish Basins ($1000)

Feature	Investment Costs					Annual Costs			Annual Benefits	
		Government								
	Private	Local	State	Federal	Total	Interest & Amortization[2]	Operation & Maintenance	Total	Total	Net
				1970-1980						
M&I Water Supply		5,440			5,440	430	73	503	503	0
Irrigation	1,350				1,350	105	120	225	225	0
Water Quality Control	2,400	1,000	500	980	4,880	267	53	320	320	0
Navigation[3]		426		1,039	1,465	69	12	81	105	24
Power					0			0	0	0
Flood Control		5,660		32,140	37,800	1,901	82	2,116[4]	3,450	1,334
Watershed Management[5]		3,412		7,225	10,637	497	97	594	2,242	1,648
Recreation	7,163	10,744	7,163	10,744	35,814	1,870	685	2,555	3,600	1,045
Fish & Wildife			11,799		11,799	621	799	1,420	1,910	490
Sub-Total	$10,913	$26,682	$19,462	$52,128	$109,185	$5,760	$1,921	$7,814[4]	$12,355	$4,541
				1980-2000						
M&I Water Supply		8,125			8,125					
Irrigation	1,100			6,000	7,100					
Water Quality Control	2,650	2,250	1,125	2,025	8,050					
Navigation[3]		2,682		6,735	9,417					
Power				68,000	68,000					
Flood Control		580		65,220	65,800					
Watershed Management[5]		592		1,258	1,850					
Recreation	8,540	12,810	8,540	12,810	42,700					
Fish & Wildife			18,909		18,909					
Sub-Total	$12,290	$27,039	$28,574	$162,048	$229,951					
				2000-2020						
M&I Water Supply		11,290			11,290					
Irrigation	2,750			15,000	17,750					
Water Quality Control	4,200	1,850	925	1,925	8,900					
Navigation[3]		747		2,242	2,989					
Flood Control					0					
Watershed Management[5]		467		993	1,460					
Recreation	14,260	21,390	14,260	21,390	71,300					
Fish & Wildlife			23,035		23,035					
Sub-Total	$21,210	$35,292	$38,220	$42,002	$136,724					
Total	$44,413	$88,922	$85,756	$256,269	$475,860					

1 Capital project costs.

2 Of initial investment and major replacement.

3 Costs and benefits for pleasure boating moorage faciliites included with Recreation.

4 $133,000 from Upper Baker storage project.

5 Structural measures installation cost only.

SEQUENCE OF DEVELOPMENT ALTERNATIVES A AND B

The projects and programs of the Comprehen sive Plan are summarized in Table 4-22 by time period. Elements listed are the same for both Alter natives A and B unless otherwise noted. Project numbers identify features on Figure 4-3.

TABLE 4-22. Future projects and programs, Skagit-Samish Basins

PROJECTS PRIOR TO 1980

Municipal and Industrial Water Supply

1. Expansion of Skagit River intake and treatment plant–Anacortes.
2. Expansion of Cultus Mountain water supply system–Skagit County PUD No. 1.
3.* Increase capacity of self-supplied industrial water system.

Irrigation

4.* Installation of individual farm irrigation pumping and sprinkler systems (private).

Water Quality Control

5.* Installation of adequate secondary treatment facilities by food processors and wood products industries.
6. Installation of facilities to remove all settleable solids from mill effluents prior to discharge with adequate outfall and diffuser–paper mill at Anacortes.
7. Installation of adequate secondary treatment facilities with disinfection by Mount Vernon, Sedro Woolley, Concrete, LaConner, Skagit County Sanitary District No. 1, and the properties of Seattle City Light.
8. Expansion of domestic system by Burlington.

Navigation

9. Deepen Guemes channel.
10. Dredge deep draft navigation channel in Fidalgo Bay.
11. Construction of small boat harbor development–LaConner, Indian Bay.
12. Enlargement of small boat harbor–Anacortes.

Flood Control

13. Construction of levee–Skagit River at Nookachamps Creek.
14. Improvement of levee and channel–Skagit River downstream from Burlington.
15. Purchase flood control storage in Upper Baker River.
16. Construction of Avon Bypass including levee from bypass entrance upstream to Sedro Woolley (size varies with Alternatives A and B).

Watershed Management

17. Small watershed multiple-purpose project–Gages Slough.
18. Small watershed multiple-purpose project–South Mount Vernon.
19. Small watershed multiple-purpose project–Samish River.
20. Small watershed multiple-purpose project–Skagit Flats.

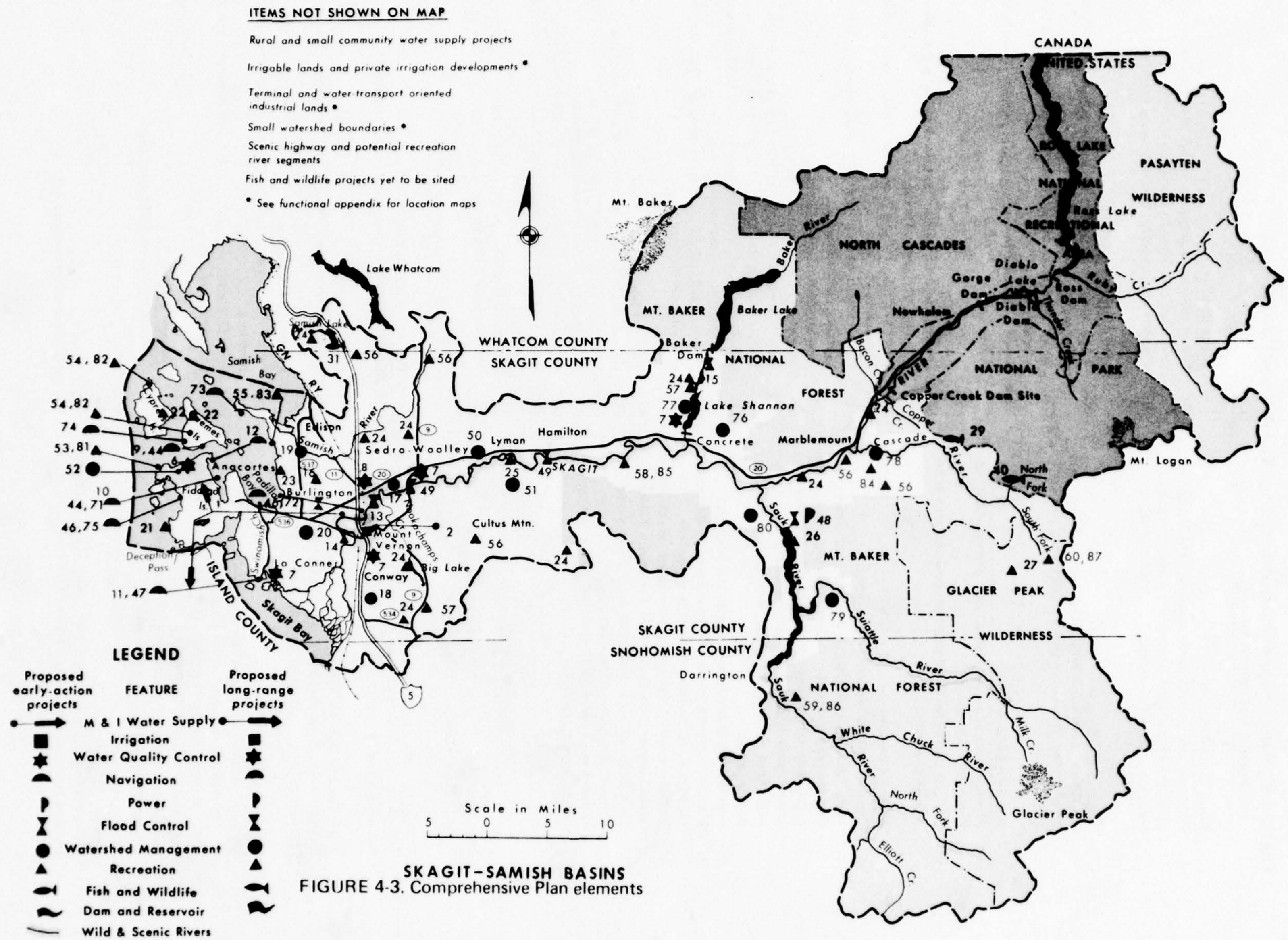
Recreation

16. Installation of recreation facilities as part of Avon Bypass project.
21. *Development of four recreation sites along the salt* water shoreline of Fidalgo Island.
22. Development of three recreation sites, total, on Cypress and Guemes Islands.
23. Development of two recreation sites along the salt water shoreline of Padilla Bay.
24. Development of one recreation site in this vicinity.
25. Development of four recreation sites along Skagit River from mouth to confluence with the Sauk River.
26. Development of two recreation sites along Sauk River from mouth to head waters.
27. Development of 40 recreation sites in the National Forest and National Park.

Fish and Wildlife

28.* Enlargement of existing fish hatcheries.
29. Construction of fish passage facilities at Cascade Falls.
30.
30.* Acquisition and development of access to eight lakes.
31. Construction of fishing piers at Samish Lake.
32.* Construction of two trout hatcheries.
33.* Construction of onc rearing pond for summer run steelhead.
34.* Construction of one rearing pond for winter run steelhead.
35.* Acquisition and development of 75 miles of stream-bank access.
36* Acquisition and development of six salt water access areas.
37.* Acquisition and development of 12,000 acres of waterfowl habitat.
38.* Acquisition of axcess to 500 acres of band-tailed pigeon areas.
39.* Enlargement of game farm to produce 5,000 additional birds.
40. Construction of fish passage facilities on North Fork Cascade River.

*Projects not shown on Figure 4-3



SKAGIT–SAMISH BASINS
FIGURE 4-3. Comprehensive Plan elements

TABLE 4-22. Future projects and programs, Skagit-Samish Basins (Cont'd)

PROGRAMS PRIOR TO 1980

Water Quality Control

a. Establish and operate water quality surveillance stations at key salt and fresh water locations and prepared comprehensive sewerage plan for the Basins.

Flood Control

b. Establish and administer county-wide flood plain zoning measures under flood plain management program.

Watershed Management

c. Provide technical assistance and management for State and Federal lands.

d. Provide technical assistance for on-farm and other private practices.

Fish and Wildlife

e. Develop lake fertilization techniques.

f. Make wildlife population analysis and timberland management practices studies, develop habitat improvement techniques and an education program on proper game hunting concepts, and begin a program with land owners for game habitat retention and hunter access.

g. Develop fish disease controls and new toxicants.

h. Conduct cross-sectional stream surveys to determine minimum and optimum streamflows for fish.

i. Locate, survey, and mark boundaries of all State-owned second class tidelands in the Basins. Take steps to reserve all such lands for public use except as required for specific circumstances.

j. Perform an inventory of shellfish stocks and recreational use of tidelands.

Projects 1980-2000

Municipal and Industrial Water Supply

41.* Expand existing water supply systems.

Irrigation

42.* Construction of project-type irrigation supply system with individual farm installation or sprinkler systems.

Water Quality Control

43.* Expansion of waste treatment and interception facilities for municipalities, industry, and recreation development.

Navigation

44. Deepen Guemes and Fidalgo Bay channels.

45. Dredge channel for deep draft navigation and construct terminal and transfer facilities and develop waterfront industrial land in Padilla Bay.

46. Development of small boat harbor—Fidalgo Island.

47. Enlargement of small boat harbor—LaConner, Indian Bay.

Power

48. Installation of power facilities at Lower Sauk multiple-purpose project—Sauk River (Alternative A only).

Flood Control

48. Flood control storage at Lower Sauk multiple-purpose project—Sauk River (Alternative A only).

49. Construction of levee—Sedro Woolley and Hamilton.

Watershed Management

50. Small watershed multiple-purpose project—North Skagit tributaries.

51. Small watershed multiple-purpose project—South Skagit tributaries.

52. Small watershed multiple-purpose project—Fidalgo Island group.

Recreation

53. Development of four recreation sites along the salt water shoreline of Fidalgo Island.

54. Development of three recreation sites, total, on Cypress and Guemes Islands.

55. Development of two recreation sites along the salt water shorelines of Padilla Bay.

56. Development of one recreation site.

57. Development of two recreation sites.

58. Development of five recreation sites along Skagit River from mouth to confluence with the Sauk River.

59. Development of three recreation sites along Sauk River from mouth to head waters.

60. Development of 50 recreation sites on National Forest and National Park lands.

Fish and Wildlife

61.* Improvement of fish habitat on 38 miles of stream.

62.* Channel clearance on 38 miles of stream.

63.* Construction of two salmon hatcheries.

64.* Construction of 2 miles of salmon spawning channel.

65.* Develop access and parking facilities at all State-owned beaches.

66.* Develop one sub-tidal park for skin divers.

67.* Improve public beaches for clam culture.

Programs 1980-2000

Water Quality Control

k. Continue water quality surveillance program.

Flood Control

l. Continue flood plain management program.

Watershed Management

m. Provide technical assistance for on-farm and other private practices.

n. Provide technical assistance and management for State and Federal lands.

Fish and Wildlife

o. Continue fish and wildife programs.

*Projects not shown on Figure 4-3.

TABLE 4-22. Future projects and programs, Skagit-Samish Basins (Cont'd)

Projects 2000-2020

Municipal and Industrial Water Supply

68.* Expand existing water supply systems.

Irrigation

69.* Installation of individual farm irrigation pumping and sprinkler systems (private).

Water Quality Control

70.* Expansion of waste treatment and interception facilities for municipalities, industry and recreation.

Navigation

71. Deepen Fidalgo Bay channel.
72. Deepen Padilla Bay channel.
73. Development of small boat harbor–Padilla Bay–Williams Point.
74. Development of small boat harbor–Guemes Island Southwest.
75. Expansion of small boat harbor–Fidalgo Island West.

Flood Control

(No further projects planned)

Watershed Management

76. Small watershed project multiple-purpose–Upper Skagit River.
77. Small watershed multiple-purpose project–Baker River.
78. Small watershed multiple-purpose project–Cascade River.
79. Small watershed multiple-purpose project–Suiattle River.
80. Small watershed multiple-purpose project–Sauk River.

Recreation

81. Development of five recreation sites along the salt water shoreline of Fidalgo Island.
82. Development of four recreation sites, total, on Cypress and Guemes Islands.
83. Development of one recreation site along the salt water shoreline of Padilla Bay.
84. Development of one recreation site.
85. Development of six recreation sites along Skagit River from mouth to confluence with the Sauk River.
86. Development of five recreation sites along Sauk River from mouth to head waters.
87. Development of 70 recreation sites on National Forest and National Park lands.

Fish and Wildlife

88.* Construction of six salmon hatcheries or equivalent.

89.* Development of 130 acres of rearing facilities.

90.* Development of 2 miles of spawning channel.

Programs 2000-2020

Water Quality Control

p. Continue water quality surveillance program.

Flood Control

q. Continue flood plain management program.

Watershed Management

r. Provide technical assistance for on-farm and other private practices.

s. Provide technical assistance and management for State and Federal lands.

Fish and Wildlife

t. Continue fish and wildife programs.

*Projects not shown on Figure 4-3.

PLAN ACCOMPLISHMENTS ALTERNATIVE A

The accomplishments of the Comprehensive Plan for Alternative A are shown in Table 4-23 for the various features of the Plan. As shown in Table 4-23 the needs for the Skagit-Samish Basins would generally be met by elements of the Comprehensive Plan except urban water management. These needs would be entirely met by the year 2020. In the preceding time periods a residual is shown, as intensive land use would be required to achieve a minimum density in order to facilitate project undertaking.

The sport and commercial fishery needs are assumed to be met by the projects contained in the Plan as the future consumptive withdrawals for municipal and industrial water supply and irrigation would not reduce the minimum flows appreciably during the critical summer season in the various rivers over that that has historically occurred. Upon completion of detailed river studies to determine the required minimum and optimum flows for fish production, as called for during the early action period, adjustments may be made to the Plan. These projects could involve adjustment in the operation of existing storage projects.

The sport and commercial fishery needs would be satisfied by the Plan assuming that present pollution problems are corrected. As only specific solutions for the early action period were provided for wildlife needs, subsequent periods were assumed to be satisfied by projects and programs that would be developed later. A reduction in hunter success is anticipated with a willingness for hunters to accept a lower success ratio necessary in order to meet project needs. Hunters also may be required to utilize hunting areas in Eastern Washington.

TABLE 4-23. Comprehensive Plan accomplishments, Alternative A, Skagit-Samish Basins

Feature	Units	To 1980			To 2000			To 2020		
		Needs	Accomp.	Residual	Needs	Accomp.	Residual	Needs	Accomp.	Residual
M&I Water Supply	mgd	21.3	21.3	0	49.1	49.1	0	88.5	88.5	0
Irrigation	1000 Acre-Feet	19.1	19.1	0	38.3	38.3	0	86.3	86.3	0
Water Quality Control										
Waste	1000 Pop. Equiv.	1,860	1,860	0	2,331	2,331	0	2,042	2,042	0
Flow [1]	cfs	240	240	0	435	435	0	650	650	0
Navigation										
Commercial	1000 Short Tons	2,200	2,200	0	6,200	6,200	0	23,600	23,600	0
Pleasure Boats [1]	Wet Moorages	1,845	850	995 [3]	3,375	3,745	(370) [4]	5,985	7,085	(1,100) [4]
Power [2]										
Flood Control	$1000 Damage Reduction	4,340	4,230	110	7,060	6,813	147	12,030	11,793	237
Watershed Management										
Flood Prevention	1000 Acres	120.9	120.9	0	120.9	120.9	0	120.9	120.9	0
Watershed Protec. & Rehabilitation [5]	1000 Acres	1,912.6	1,912.6	0	1,912.6	1,912.6	0	1,912.6	1,912.6	0
Water Management [6]										
Agricultural	1000 Acres	49.0	49.0	0	81.7	81.7	0	108.9	108.9	0
Urban	1000 Acres	38.9	16.9	22.0	38.9	27.5	11.4	38.9	38.9	0
Recreation	1000 User-Days	3,000	3,000	0	7,000	7,000	0	13,900	13,900	0
Fish & Wildlife										
Sport										
Fishing	1000 User-Days	572	572	0	1,431	1,431	0	2,828	2,828	0
Hunting	1000 User-Days	148	148	0	339	339	0	455	455	0
Commercial Fishing	1000 Pounds	360	360	0	3,692	3,692	0	7,940	7,940	0

1 Skagit River.

2 Power needs were projected for the Puget Sound Area only.

3 Residual wet moorage needs assumed to be satisfied by private developments.

4 Surplus wet moorages provided to satisfy spillover needs from Stillaguamish Basin.

5 The necessary level of management is assumed to be established throughout the Basins, otherwise some residual could occur.

6 Needs and accomplishments are cumulative.

Under Alternative A the Avon Bypass with a capacity of 60,000 cfs, downstream levee and channel improvements, flood control storage on Baker River and levee improvements at Nookachamps Creek, would provide about 50-year protection for Burlington and Mount Vernon and for the remainder of the 68,000-acre flood plain downstream from Sedro Woolley by 1980. (Minor reduction in the frequency and depth of flooding upstream of Sedro Woolley from the Baker River flood storage is not reflected in the tables). With additional levees at Sedro Woolley and Hamilton, and storage on the Sauk River, 100-year protection would be provided for Sedro Woolley and Hamilton, the agricultural area downstream from Sedro Woolley, and for the large urbanized area at Burlington and Mount Vernon; and 15-25 year protection for the agricultural areas upstream from Sedro Woolley. Residual average annual damages would be reduced by the above structural measures and implementation of flood plain management to $110,000 for 1980 and $237,000 by the year 2020 as shown in Table 4-23.

SUMMARY OF PLAN ALTERNATIVE B

Alternative B is the same as Alternative A except for flood control, power and recreation features. Flood control features differ in both the early action and long-range phases of the Plan, with the Lower Sauk storage project omitted from long-range consideration in Alternative B. Hydroelectric power development as a purpose of the Lower Sauk project also is excluded. Recreation features only differ with regard to the inclusion in Alternative B of designated portions of the Skagit River and tributaries in a National Wild and Scenic Rivers system. Only the flood control and recreation features of Alternative B are discussed in the following section.

Early Action, 1970-1980

During this period 100,000 acre-feet of flood control storage would be obtained by changing the operation of the Upper Baker project. The Avon Bypass also would be constructed in conjunction with downstream levee and channel improvements. The Bypass would be sized for a flow of 100,000 cfs under Alternative B. A levee would be constructed at Nookachamps Creek before 1980. Flood plain management by land use zoning of lands would control development in the flood plain consistent with the levels of flood protection. Floodproofing and warning systems also would be implemented. These measures would contribute significantly to the reduction of future flood damages and are relied upon to large measure in Alternative B to reduce future flood damages above Sedro Woolley.

About 165 miles of the Skagit River and tributaries would be classified as "Recreational Rivers" in the National Wild and Scenic Rivers system.

Table 4-24 summarizes all the elements of Alternative B, showing the benefits and costs for the early action portion of the Plan, and provides a summary of investment costs by water resource functions for the entire 50-year period ending in 2020. The early action portion of the Plan includes programs amounting to $88,414,000 and projects costing $117,185,000 for a total investment of $205,599,000. Program and project investment costs for the 1980-2000 period amount to $203,905,000 and for the 2000-2020 period $246,830,000. A total 50-year investment amounts to $656,334,000 for Alternative B.

TABLE 4-24. Comprehensive Plan, Alternative B, Skagit-Samish Basins

Feature	Items	1970-1980 Investment[1] Costs ($1000)	1970-1980 Average Annual Costs ($1000)	1970-1980 Average Annual Benefits Gross ($1000)	1970-1980 Average Annual Benefits Net ($1000)	1980-2000 Investment Costs ($1000)	2000-2020 Investment Costs ($1000)	1970-2020 Investment Costs ($1000)
Management Programs								
Water Quality Control	Monitoring, Evaluation and Control	490	--	--	--	360	420	1,270
Flood Control	Flood Control Management	115	--	--	--	168	168	451
Watershed Management	Programs	87,556	--	--	--	99,226	109,318	296,100
Fish and Wildlife	Programs	253	--	--	--	200	200	653
Total Programs		$ 88,414				$ 99,954	$110,106	$298,474
Nonstorage Projects								
M&I Water Supply	Ground Water Use	0	0	0	0	565	905	1,470
	Surface Water Use	5,440	503	503[4]	0	7,560	10,385	23,385
Irrigation Water Supply	Ground Water Use	1,072	179	179[4]	0	3,400	3,750	8,222
	Surface Water Use	278	46	46[4]	0	3,700	14,000	17,978
Water Quality Control	Sewerage Treatment and Collection Facilities	4,880	320	320[4]	0	8,050	8,900	21,830
Navigation	Channels	1,465	81	105	24	9,417	2,989	13,871
	Small Boat Harbors[3]	(1,714)[3]	(109)[3]	(159)[3]	(50)[3]	(3,831)[3]	(3,830)[3]	(9,375)[3]
Power[2]								
Flood Control	Levee and Channels	45,800	2,403	3,478	1,075	7,800	0	53,600
Watershed Management	Floodwater Damage Reduction, Water Management, and Protection and Rehabilitation	10,637	594	2,242	1,648	1,850	1,460	13,947
Recreation	Land Acquisition, Access and Enhancement Facilities	35,814	2,555	3,600	1,045	42,700	71,300	149,814
Fish and Wildlife	Land Acquisition, Access and Enhancement Facilities	11,799	1,420	1,910	490	18,909	23,035	53,243
Total Nonstorage		$117,185	$8,101	$12,383	$4,282	$103,951	$136,724	$357,860
Storage Project								
Flood Control	Upper Baker		133	300	167			
Total Programs and Projects		$205,599	$8,234	$12,683	$4,449	$203,905	$246,830	$656,334

1 Includes cumulative annual program costs for the period for management features and capital costs for nonstorage projects.

2 Nonstorage power development not included in the Plan.

3 General navigation facilities costs and benefits for public small boat harbors only. Total pleasure boat facilities costs and benefits included with Recreation.

4 Average annual benefits assumed equal to average annual costs.

FEATURES OF THE COMPREHENSIVE PLAN ALTERNATIVE B

Flood Control

Industrial and urban lands within the Basins have been recommended for 100-year level of flood protection, agricultural lands at least 25-year level of protection and lands along the flood plain to be used for parks, golf courses and general recreation requiring a level of protection of 10-15 years. Implementation of the Comprehensive Plan would reduce flood damages in the Skagit-Samish Basins. Under Alternative B (without the Sauk River storage project) the desirable objectives would not be met.

Flood plain management measures such as floodproofing, flood plain zoning, or other positive means of land use control would be implemented. Sufficient lands are considered to be available within the Skagit-Samish Basins to preclude the necessity of intensive development in unprotected flood plains. However, without flood plain zoning structural measures such as storage projects may be needed beyond those provided in the Plan. Uncontrolled encroachments on the flood plain by residential and industrial developments would require expensive structural flood control measures to protect these high value investments.

That portion of the Comprehensive Plan dealing with flood control is discussed below.

1970-1980–During this period 100,000 acre-feet of flood control storage in the existing reservoir on Baker River at the Upper Baker project would be purchased. The lost power-producing capability would be compensated at an estimated cost of $133,000 annually. Also requiring early action would be construction of the Avon Bypass. The size of the Bypass under Alternative B would be for a flow of 100,000 cfs and would cost $36,300,000. The existing levees and channel downstream from Burlington would be improved before 1980 as well as the levees along the left bank of the Skagit River at Nookachamps Creek, between Mount Vernon and Sedro Woolley. The levees along the Skagit River at Nookachamps Creek would cost an estimated $2,500,000 to construct. These features including the Upper Baker River storage and the existing 120,000 acre-feet of flood control storage in Ross Reservoir would be designed to provide 50-year flood protection for Burlington and Mount Vernon and 25-year protection for the large farming area in the vicinity and downstream of Burlington and Mount Vernon for the Nookachamps Creek area. The Nookachamps Creek levees would be designed to be overtopped before levees at Burlington and Mount Vernon were overtopped to assure that the valley storage at Nookachamps Creek remains available for flood protection storage for the major urban areas of the Basins during large and infrequent floods. To achieve the same (100-year) level of protection for urban areas as would be possible with the Lower Sauk project a slightly higher levee between Burlington and the high ground near Sedro Woolley would be required under Alternative B. The levee and channel improvements downstream from Burlington would amount to $7,000,000, resulting in a channel capacity downstream from the Avon Bypass intake of 120,000 cfs.

Flood plain management measures, including a warning system and land use zoning, would be important tools for mitigating future flood damages. Flood plain zoning costs include $31,000 for local preparation of a flood plain zoning plan and $8,400 annually for implementation of the plan. These expenditures would be justified by the reduction of about $480,000 in average annual flood damages.

The tabulation below summarizes the early action flood control programs and projects for the Skagit-Samish Basins under Alternative B.

Flood Control Element	Effective Flood Control Storage (ac. ft.)	River Mile	Height of Dam (cfs)	Design Capacity (cfs)	Investment Costs ($1000)	Average Annual Costs Interest & Amortization ($1000)	Average Annual Costs Operation & Maintenance ($1000)	Average Annual Costs Total ($1000)	Average Annual Benefits ($1000)
Flood Control Storage Projects									
Upper Baker	100,000	9.0	330					133	300
Channel and Levee Construction									
Avon Bypass				100,000	36,300	1,835	85	1,920	2,475
Levee and channel improvement from Burlington-Mount Vernon area downstream to mouth of both Forks				120,000	7,000	344	10	354	853
Levee Construction									
Levees at Nookachamps Creek area				135,000	2,500	123	6	129	150
Subtotal					$45,800	$2,302	$101	$2,536	$3,778
Flood Plain Management					115				480
Total–Alt. B					$45,915				

1980-2000–Under Alternative B only levees would be constructed at Hamilton (3 miles) and Sedro Woolley (4 miles) at an estimated $3,800,000 and $4,000,000, respectively. The levee costs are greater under this Alternative for the same level of protection as Alternative A. A higher flow would have to be contained without the Lower Sauk storage project. Flood plain management cost would amount to $168,000.

2000-2020–Flood plain management would be continued during this period at a cost of $168,000. No further structural measures are anticipated.

Recreation

The recreation features of the Comprehensive Plan, including number of sites developed and general locations, would be the same as Alternative A. Recreation investment costs, for the purpose of this study, were taken as being the same as Alternative A although it is recognized that some additional costs could result from acquiring select portions of the Skagit River and tributaries as part of the National Wild and Scenic Rivers system.

Under Alternative B the following portion of the Skagit River and its tributaries would be included in the National Wild and Scenic Rivers system before 1980 and given a "Recreational" classification.

Alternative B
Segments of the Skagit River and Tributaries to be Considered in the National Wild and Scenic Rivers Study

		Miles
Skagit	Mount Vernon to and including the mouth of Bacon Creek	70
Cascade	Mouth to junction of its North and South Forks	17
Cascade, S. Fork	Mouth to Glacier Peak Wilderness area	2
Suiattle	Mouth to Glacier Peak Wilderness area at Milk Creek	28
Sauk	Mouth to junction with Elliott Creek	38
Sauk, N. Fork	Mouth to Glacier Peak Wilderness area	10
Total		165

Investment costs for the years 1980, 2000 and 2020 are presented in the tabulation below.

Outdoor Recreation Improvements

Feature	1970-1980 Investment Costs ($1000)	1980-2000 Investment Costs ($1000)	2000-2020 Investment Costs ($1000)	Total Investment Costs ($1000)
Campgrounds	12,824			
Picnic Areas	1,085			
Beaches	84			
Swimming Pools	850			
Boating Facilities	3,666			
Planning and Design	4,627			
Land Acquisition	12,678			
Total	$35,814	$42,700	$71,300	$149,814

COST-BENEFIT SUMMARY ALTERNATIVE B

The investment costs by resource feature are shown in Tables 4-25 and 4-26 for the Skagit-Samish Basins with the costs distributed between Federal, State, local, and private interests. Average annual costs and benefits also are shown for projects recommended for implementation prior to 1980. The investment costs include cumulative annual program costs for each of the three planning periods as shown in Table 4-25 and capital project costs as shown in Table 4-26. Interest and amortization costs are based on a 100-year economic life with appropriate allowances made for major replacements. An interest rate of 4-5/8 percent was used in the economic analysis. All measures proposed for early action are justified on the basis of tangible benefits. Benefits for M&I water supply and water quality improvement were assumed equal to annual charges.

Investment costs were allocated to the various interests on the basis of available information including the technical appendices, multiple-project studies, and experience at similar projects.

SEQUENCE OF DEVELOPMENT ALTERNATIVE B

The projects and programs of Alternative B are shown in Table 4-22 with projects identified on Figure 4-3. Elements differing with Alternative A are noted.

TABLE 4-25. Program investment costs,[1] Alternative B, Skagit-Samish Basins ($1000)

Feature	Private	Government Local	Government State	Government Federal	Total
			1970-1980		
Water Quality Control	83	83	226	98	490
Flood Control		90	17	8	115
Watershed Management	42,685	7,988	4,888	31,995	87,556
Fish and Wildlife			253		253
Subtotal	$ 42,768	$ 8,161	$ 5,384	$ 32,101	$ 88,414
			1980-2000		
Water Quality Control	64	64	164	68	360
Flood Control		117	34	17	168
Watershed Management	43,765	6,554	6,517	42,390	99,226
Fish and Wildlife			200		200
Subtotal	$ 43,829	$ 6,735	$ 6,915	$ 42,475	$ 99,954
			2000-2020		
Water Quality Control	70	70	196	84	420
Flood Control		117	34	17	168
Watershed Management	58,554	7,244	6,517	37,003	109,318
Fish and Wildlife			200		200
Subtotal	$ 58,624	$ 7,431	$ 6,947	$ 37,104	$110,106
Total	$145,221	$22,327	$19,246	$111,680	$298,474

[1] Cumulative annual program costs over the period.

TABLE 4-26. Project investment costs[1] and cost-benefit summary, Alternative B, Skagit-Samish Basins ($1000)

Feature	Investment Costs					Annual Costs			Annual Benefits	
		Government				Interest	Operation			
	Private	Local	State	Federal	Total	& Amortization[2]	& Maintenance	Total	Total	Net
			1970-1980							
M&I Water Supply		5,440			5,440	430	73	503	503	0
Irrigation	1,350				1,350	105	120	225	225	0
Water Quality Control	2,400	1,000	500	980	4,880	267	53	320	320	0
Navigation[3]		426		1,039	1,465	69	12	81	105	24
Power					0			0	0	0
Flood Control		7,060		38,740	45,800	2,302	101	2,536[4]	3,778	1,242
Watershed Management[5]		3,412		7,225	10,637	497	97	594	2,242	1,648
Recreation	7,163	10,744	7,163	10,744	35,814	1,870	685	2,555	3,600	1,045
Fish and Wildlife			11,799		11,799	621	799	1,420	1,910	490
Subtotal	$10,913	$28,082	$19,462	$ 58,728	$117,185	$6,161	$1,940	$8,234[4]	$12,683	$4,449
			1980-2000							
M&I Water Supply		8,125			8,125					
Irrigation	1,100			6,000	7,100					
Water Quality Control	2,650	2,250	1,125	2,025	8,050					
Navigation[3]		2,682		6,735	9,417					
Power				68,000	68,000					
Flood Control		780		7,020	7,800					
Watershed Management[5]		592		1,258	1,850					
Recreation	8,540	12,810	8,540	12,810	42,700					
Fish and Wildlife			18,909		18,909					
Subtotal	$12,290	$27,239	$28,574	$ 35,848	$103,951					
			2000-2020							
M&I Water Supply		11,290			11,290					
Irrigation	2,750			15,000	17,750					
Water Quality Control	4,200	1,850	925	1,925	8,900					
Navigation[3]		747		2,242	2,989					
Flood Control					0					
Watershed Management[5]		467		993	1,460					
Recreation	14,260	21,390	14,260	21,390	71,300					
Fish and Wildlife			23,035		23,035					
Subtotal	$21,210	$35,292	$38,220	$ 42,002	$136,724					
Total–Alt. B	$44,413	$90,522	$85,756	$136,669	$357,860					

1 Capital project costs.

2 Of initial investment and major replacement.

3 Costs and benefits for pleasure boating moorage facilities included with Recreation.

4 $133,000 from Upper Baker storage project.

5 Structural measures installation cost only.

PLAN ACCOMPLISHMENTS ALTERNATIVE B

The accomplishments of the Comprehensive Plan for Alternative B are shown in Table 4-27 for the various features of the Plan. As shown in Table 4-27 the needs for the Skagit-Samish Basins would be met by elements of the Comprehensive Plan except for flood control and urban water management. The latter needs would be entirely met by the year 2020. In the preceding time periods a residual is shown, as intensive land use would be required to achieve a minimum density in order to facilitate project undertaking.

Under Alternative B the Avon Bypass with a capacity of 100,000 cfs, downstream levee and channel improvements, flood control storage on Baker River and levee improvements at Nookachamps Creek, would provide, by 1980, 100-year protection for Burlington and Mount Vernon and for the remainder of the 68,000-acre flood plain downstream from Sedro Woolley. Levees constructed after 1980 at Sedro Woolley and Hamilton would be designed to provide 100-year protection for these towns. The agricultural areas upstream from Sedro Woolley would not receive any further protection. This lack of further protection is reflected in Table 4-27 which indicates a residual average annual damages under Alternative B of $437,000 by the year 2020.

COMPARATIVE EVALUATION OF ALTERNATIVES A AND B

This section discussed the need in the Skagit-Samish Basins for (1) maximum development of flood control opportunities, and (2) designation of portions of the Skagit River and tributaries for inclusion in a national, wild and scenic river system.

Need and Development—Alternative A

The 90,000-acre flood plain of the Skagit River contains extensive agricultural and urban developments which are exposed to excessive flood hazards. Levees in combination with the existing upstream storage are capable of providing only 3 to 15-year protection to the 68,000-acre flood plain west of Sedro Woolley. No levee protection exists upstream of Sedro Woolley where flooding occurs on the average of once every two years, damaging farms, cropland and transportation facilities. Current annual flood damages are estimated to be $3,020,000, in 1966 prices and conditions. Future average annual flood damages are expected to increase in proportion to the increase in economic activity in the flood plain if additional protection is not provided. The trend of development within the Basins could result in future growth of flood damages without flood control amounting to $4,340,000 by 1980 and over $12 million by the year 2020.

Under Alternative A with the 134,000 acre-feet of flood control storage made possible by the Lower Sauk project, a maximum degree of flood protection would be provided enabling optimum development and utilization of the Skagit Basin flood plain. Increased flood protection would be possible for the agricultural lands and the highway and rail system above the town of Sedro Woolley. The areas downstream from Sedro Woolley would receive 100-year flood protection. Although considered marginal at this time, power would be included as a feature of the Lower Sauk project. This project would reduce peak flood flows as measured at Sedro Woolley by about 40,000 cfs for flood with a 100-year recurrence interval. The flood plain above Sedro Woolley would receive a 15 to 25-year level of protection.

Need and Development—Alternative B

The Skagit River is the largest river in the Puget Sound Area and the most *significant* for recreational use, with its principal tributaries the Sauk, Suiattle, and Baker Rivers providing pleasure for residents as well as recreationists from the entire State. The upper reaches of the Skagit River Basin are mountainous with deep valleys and turbulent streams. State Highway 20, which bisects Interstate 5 a few miles above Mount Vernon follows the Skagit River up to the Ross Lake where the highway is under construction to allow passage over the Cascade Mountains into Eastern Washington. The Skagit Basin runs over the Cascade Mountains into Eastern Washington. The Skagit Basin has attractive mountains, wilderness, streams, lakes, salt water, islands, and shorelands. Salmon and steelhead runs and the man-made Baker, Diablo, and Ross Lakes are outstanding attractions. The Basin is relatively undisturbed above Sedro Woolley providing a natural environment for a variety of recreational uses. The shoreline of the Skagit, Sauk and Suiattle Rivers are capable of accommodating a large number of recreation areas. The tree-lined channels of these rivers provide boaters with an attractive setting for this form of recreational activity.

TABLE 4-27. Comprehensive Plan accomplishments, Alternative B, Skagit-Samish Basins

Feature	Units	To 1980			To 2000			To 2020		
		Needs	Accomp.	Residual	Needs	Accomp.	Residual	Needs	Accomp.	Residual
M&I Water Supply	mgd	21.3	21.3	0	49.1	49.1	0	88.5	88.5	0
Irrigation	1000 Acre-Feet	19.1	19.1	0	38.3	38.3	0	86.3	86.3	0
Water Quality Control										
Waste	1000 Pop. Equiv.	1,860	1,860	0	2,331	2,331	0	2,042	2,042	0
Flow[1]	cfs	240	240	0	435	435	0	650	650	0
Navigation										
Commercial	1000 Short Tons	2,200	2,200	0	6,200	6,200	0	23,600	23,600	0
Pleasure Boats[1]	Wet Moorages	1,845	850	995[3]	3,375	3,745	(370)[4]	5,985	7,085	(1,100)[4]
Power[2]										
Flood Control	$1000 Damage Reduction	4,340	4,250	90	7,060	6,753	307	12,030	11,593	437
Watershed Management										
Flood Prevention	1000 Acres	120.9	120.9	0	120.9	120.9	0	120.9	120.9	0
Watershed Protec. & Rehabilitation[5]	1000 Acres	1,912.6	1,912.6	0	1,912.6	1,912.6	0	1,912.6	1,912.6	0
Water Management[6]										
Agricultural	1000 Acres	49.0	49.0	0	81.7	81.7	0	108.9	108.9	0
Urban	1000 Acres	38.9	16.9	22.0	38.9	27.5	11.4	38.9	38.9	0
Recreation	1000 User-Days	3,000	3,000	0	7,000	7,000	0	13,900	13,900	0
Fish & Wildlife										
Sport										
Fishing	1000 User-Days	572	572	0	1,431	1,431	0	2,828	2,828	0
Hunting	1000 User-Days	148	148	0	339	339	0	455	455	0
Commercial Fishing	1000 Pounds	360	360	0	3,692	3,692	0	7,940	7,940	0

1 Skagit River.

2 Power needs were projected for the Puget Sound Area only.

3 Residual wet moorage needs assumed to be satisfied by private developments.

4 Surplus wet moorages provided to satisfy spillover needs from Stillaguamish Basin.

5 The necessary level of management is assumed to be established throughout the Basins, otherwise some residual could occur.

6 *Needs and accomplishments are cumulative.*

The Skagit River is one of the few rivers in the Puget Sound Area that remains relatively untouched in terms of development. It offers an unusual opportunity for retention in a natural state.

Congress, in Public Law 90-542, recognized the special attributes of the Skagit Basin and designated in that act portions of the Skagit River and tributaries as potential additions to the national wild and scenic system. Congress indicated that the Skagit River by its selection for study was one of certain rivers in the Nation which may in its immediate environments possess outstanding and remarkable scenic, recreational, geological, fish and wildlife features which should be preserved in a free-flowing condition for the benefit and enjoyment of present and future generations. Congress also declared that "... the established national policy of dam and other construction at appropriate sections of the rivers of the United States needs to be complemented by a policy that would preserve other selected rivers or sections thereof in their free-flowing condition to protect the water quality of such rivers and to fulfill other vital national conservation purposes."

Due to the existence of roads and developments the Skagit, Sauk, Suiattle, and Cascade Rivers would probably be considered for the national recreational river classification. Under the recreational river classification, the section of rivers designated are readily accessible by road or railroad and may have some development along their shorelines.

Under Alternative B, the Sauk River project would not be constructed and the following portions of the Skagit would be included in the national system:

Alternative B
Segments of the Skagit River and
Tributaries to be Considered and
for Inclusion in the
National Wild and Scenic Rivers System

		Miles
Skagit	Mount Vernon to and including the mouth of Bacon Creek	70
Cascade	Mouth to junction of its North and South Forks	17
Cascade, South Fork	Mouth to Glacier Peak Wilderness Area	2
Suiattle	Mouth to Glacier Peak Wilderness Area at Milk Creek	28
Sauk	Mouth to junction with Elliott Creek	38
Sauk, North Fork	Mouth to Glacier Peak Wilderness Area	10

Further flood control to protect the agricultural lands and transportation system above Sedro Woolley would generally be precluded under this alternative. An enlarged Avon Bypass would be necessary below Burlington in order to provide the

same degree of protection as would be possible with the combination projects planned under Alternative A. The flows in the Skagit River would still be subject to fluctuations as a result of operation of the existing hydroelectric projects on the upper Skagit River and on the Baker River; however, the stream segments that would be in the national system would be free of any impoundments.

Summation

Alternative A may be viewed as primarily responsive to Basin or local needs although national benefits would result from planned programs and projects. Flood damage reduction is a major need of the Skagit-Samish Basins with planning under Alternative A providing for maximum flood control that can be economically justified.

Alternative B is directly responsive to a national need for preservation of certain rivers having outstanding environmental quality attributes. As Congress has set a five-year moratorium on construction of impoundments on that portion of the Skagit River and tributaries under study, a national or Federal interest is evident. Inclusion of the Skagit River in the National Wild and Scenic Rivers system would primarily satisfy a regional or national need. Consequently, a decision which is made regarding implementation of Alternative A or B, or variations thereof, must recognize impacts on the local economy. If national needs are viewed as paramount to local need for optimum flood damage reduction, then the questions of compensation for foregone opportunities and adjustment for local cost-sharing of improvements would need to be considered.

The enlarged Avon Bypass, required under Alternative B to accomplish the same degree of flood protection below Sedro Woolley as would be possible under Alternative A, would greatly increase the local share of flood control costs. Consideration should, therefore, be given to having these increased costs paid by other than the local interests. Further, many of the highway bridge costs, as previously stated, are due to services rendered to highway users outside the Skagit-Samish Basins. The special interests served in both cases would be partially State and Federal. Consequently, whether the Lower Sauk project is constructed or not, there appears to be justification for considering Federal, and possibly State, assumption of a part of the costs of lands, relocations and bridges for the Avon Bypass.

ALTERNATIVE ELEMENTS

Alternative measures considered to those elements contained in the Comprehensive Plan and reasons for not adopting these alternatives are discussed in this section.

Alternatives to Municipal and Industrial Water Supply and Irrigation Elements

The surface water resources of the Skagit Basin are more than adequate to meet the projected municipal and industrial water supply needs without appreciably reducing the flows available for fish. However, several alternatives to the proposed solutions were briefly examined. These included desalinization and use of the Skagit River by both Anacortes and Skagit County PUD No. 1. Desalinization, considered because of the possibility of nuclear power plant development, was not found to be economically competitive at this time. The switchover by the PUD from the existing Cultus Mountain system would require considerable investment to duplicate existing facilities. As this resource appeared to be adequate to meet projected needs, further development of the Cultus system was proposed as part of the Comprehensive Plan.

Alternative to Flood Control Elements

The means that were investigated for reducing future flood damage include nonstructural measures such as flood plain zoning, floodproofing of existing structures, and relocation of damageable facilities to flood free areas; local protection including levees, flood walls, channel enlargement and side channel diversions; storage including single and multiple-purpose reservoirs, and interbasin diversions. Flood plain zoning would be an important part of the Comprehensive Plan for the Skagit-Samish Basins. Floodproofing of new structures in floodprone areas would be made a part of the zoning requirements. Floodproofing of existing buildings where practicable, should be the owner's responsibility. Relocation was found to be generally too expensive to warrant more than a cursory investigation. Diversion of flood flows from the Sauk River near Darrington into the Stillaguamish River would be technically feasible, but would not have economic justification.

Consideration was given to controlling floods through construction of small headwater dams. Such dams, however, are usually expensive for the value

received. Occasional localized flood control benefits might be realized from small dam construction to control a troublesome small stream. Generally, small dams would not provide any significant reduction of large floods on main streams. Such projects can actually cause small increases in main-stem floods by withholding small tributary peak flows before the main-stem crest is reached and gradually releasing the stored water as the main-stem crest reaches the small tributary.

Alternatives to Recreation and Fish and Wildlife Measures

As limited information was provided with regard to specific locations of recreation developments, no analysis could be made to determine if sites and proposed developments selected were necessarily the most economical that could be provided to achieve a given amount of recreation benefits. Fish and wildlife measures contained in Appendix XI, Fish and Wildlife, were generally found to be compatible with the other elements of the Comprehensive Plan and were included in total. However, in lieu of the flood control and low flow augmentation, proposed in Appendix XI, enlargement of existing salmon hatcheries and construction of a fish passage facility at falls on the North Fork of the Cascade River were provided to satisfy 1980 needs. Although flood control storage at Baker Dam and construction of the Avon Bypass would benefit fish by reducing flood peaks in the Skagit River, the amount of benefits were not evaluated in this study.

All fish and wildlife measures proposed after 1980 were included in the Comprehensive Plan with the exception of storage projects to provide flood control and low flow augmentation on the main-stem and tributaries of the Skagit and Samish Rivers. As no flows were specified in Appendix XI, Fish and Wildlife, for low flow augmentation or the level of flood control required in order to obtain a given level of fish benefits, storage projects on small tributaries were not investigated. Completion of the cross-sectional study surveys recommended in Appendix XI, Fish and Wildlife, for early action by 1980 would provide data from which further studies of projects can be undertaken to determine if these projects are justified and desirable on the basis of flood damage reduction for both real property and fish propagation as well as low flow augmentation.

In lieu of the flood control and low flow augmentation measures recommended on the main-stem and tributaries of the Skagit and Samish Rivers for the period 1980-2000, artificial propagation facilities were provided.

EXHIBIT

SKAGIT–SAMISH BASIN
EXCERPTS FROM THE
WILD AND SCENIC RIVERS ACT

Pertinent portions of the Wild and Scenic Act (P.L. 90-542, October 2, 1968) are quoted as follows:

"(b) It is hereby declared to be the policy of the United States that certain selected rivers of the Nation which, with their immediate environments, possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values, shall be preserved in free-flowing condition, and that they and their immediate environments shall be protected for the benefit and enjoyment of present and future generations. The Congress declares that the established national policy of dam and other construction at appropriate sections of the rivers of the United States needs to be complemented by a policy that would preserve other selected rivers or sections thereof in their free-flowing condition to protect the water quality of such rivers and to fulfill other vital national conservation purposes.

"(c) The purpose of this Act is to implement this policy by instituting a national wild and scenic rivers system, by designating the initial components of that system, and by prescribing the methods by which and standards according to which additional components may be added to the system from time to time.

"Sec. 2."---(b) A wild, scenic or recreational river area eligible to be included in the system is a free-flowing stream and the related adjacent land area that possesses one or more of the values referred to in section 1, subsection (b) of this Act.

"(1) Wild river areas–Those rivers or sections of rivers that are free of impoundments and generally inaccessible except by trail, with watersheds or shorelines essentially primitive and water unpolluted. These represent vestiges of primitive America.

"(2) Scenic river areas–Those rivers or sections of rivers that are free of impoundments, with shorelines or watersheds still largely primitive and shorelines largely undeveloped, but accessible in places by roads.

"(3) Recreation river areas–Those rivers or sections of rivers that are readily accessible by road or railroad, that may have some development along their shorelines, and that may have undergone some impoundment or diversion in the past.

"Sec. 3 (b) The agency charged with the administration of each component of the national wild and scenic rivers system designated by subsection (a) of this section shall, within one year from the date of this Act, establish detailed boundaries therefore (which boundaries shall include an average of not more than three hundred and twenty acres per mile on both sides of the river); determine which of the classes outlined in section 2, subsection (b), of this Act best fit the river or its various segments; and prepare a plan for necessary developments in connection with its administration in accordance with such classification. Said boundaries, classification, and development plans shall be published in the Federal Register and shall not become effective until ninety days after they have been forwarded to the President of the Senate and the Speaker of the House of Representatives.

"Sec. 4 (a) The Secretary of the Interior or, where national forest lands are involved, the Secretary of Agriculture or, in appropriate cases, the two Secretaries jointly shall study and from time to time submit to the President and the Congress proposals for the addition to the national wild and scenic rivers system of rivers which are designated herein or hereafter by the Congress as potential additions to such system; which, in his or their judgment, fall within one or more of the classes set out in section 2, subsection (b), of this Act; and which

are proposed to be administered, wholly or partially, by an agency of the United States. Every such study and plan shall be coordinated with any water resources planning involving the same river which is being conducted pursuant to the Water Resources Planning Act (79 Stat. 244; 42 U.S.C. 1962 et seq.).

"Sec. 5 (a) The following rivers are hereby designated for potential addition to the national wild and scenic rivers sytem:

"(24) Skagit, Washington: The segment from the town of Mount Vernon to and including the mouth of Bacon Creek; the Cascade River between its mouth and the junction of its North and South Forks; the South Fork to the boundary of the Glacier Peak Wilderness Area; the Suiattle River from its mouth to the Glacier Peak Wilderness Area boundary at Milk Creek; the Sauk River from its mouth to its junction with Elliott Creek; the North Fork of the Sauk River from its junction with the South Fork of the Sauk to the Glacier Peak Wilderness Area boundary.

"(b) The Secretary of the Interior and where national forest lands are involved, the Secretary of Agriculture shall proceed as expeditiously as possible to study each of the rivers named in subsection (a) of this section in order to determine whether it should be included in the national wild and scenic rivers system. Such studies shall be completed and reports made thereon to the President and the Congress, as provided in section 4 of this Act, within ten years from the date of this Act.

In conducting these studies the Secretary of the Interior and the Secretary of Agriculture shall give priority to those rivers with respect to which there is the greatest likelihood of developments which, if undertaken, would render them unsuitable for inclusion in the national wild and scenic rivers system.

"(c) The study of any of said rivers shall be pursued in as close cooperation with appropriate agencies of the affected State and its political subdivisions as possible, shall be carried on jointly with such agencies if request for such joint study is made by the State, and shall include a determination of the degree to which the State or its political subdivisions might participate in the preservation and administration of the river should it be proposed for inclusion in the national wild and scenic rivers system.

"(d) In the planning for the use and development of water and related land resource, consideration shall be given by all Federal agencies involved to potential national wild, scenic, and recreational river areas, and all river basin and project plan reports submitted to the Congress shall consider and discuss any such potentials. The Secretary of the Interior and the Secretary of Agriculture shall make specific studies and investigations to determine which additional wild, scenic and recreational river areas within the United States shall be evaluated in planning reports by all Federal agencies as potential alternative uses of the water and related land resources involved.

"Sec. 7 (b) The Federal Power Commission shall not license the construction of any dam, water conduit, reservoir, powerhouse, transmission line, or other project works under the Federal Power Act, as ammended, on or directly affecting any river which is listed in section 5, subsection (a), of this Act, and no department or agency of the United States shall assist by loan, grant, license, or otherwise the construction of any water resources project that would have a direct and adverse effect on the values for which such river might be designated as determined by the Secretary responsible for its study or approval.

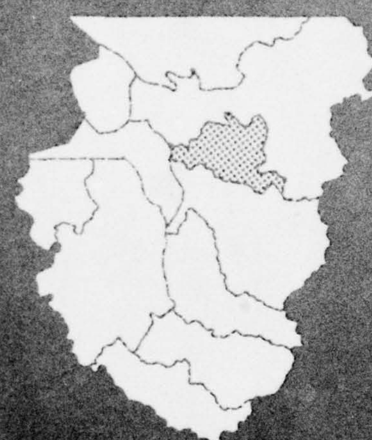
"(i) during the five-year period following enactment of this Act unless, prior to the expiration of said period, the Secretary of the Interior and, where national forest lands are involved, the Secretary of Agriculture, on the basis of study, conclude that such river should not be included in the national wild and scenic rivers system and publish notice to that effect in the Federal Register, and

"(ii) during such additional period thereafter as, in the case of any river which is recommended to the President and the Congress for inclusion in the national wild and scenic rivers system, is necessary for congressional considera-

tion thereof or, in the case of any river recommended to the Secretary of the Interior for inclusion in the national wild and scenic rivers system under section 2 (a) (ii) of this Act, is necessary for the Secretary's consideration thereof, which additional period, however, shall not exceed three years in the first case and one year in the second.

"Nothing contained in the foregoing sentence, however, shall preclude licensing of, or assistance to, developments below or above a potential wild, scenic or recreational river area or on any stream tributary thereto which will not invade the area or diminish the scenic, recreational, and fish and wildlife values present in the potential wild, scenic or recreation river area on the date of approval of this Act. No department or agency of the United States shall, during the periods hereinbefore specified, recommend authorization of any water resources project on any such river or request appropriations to begin construction of any such project, whether heretofore or hereafter authorized, without advising the Secretary of the Interior and, where national forest lands are involved the Secretary of Agriculture in writing of its intention so to do at least sixty days in advance of doing so and without specifically reporting to the Congress in writing at the time it makes its recommendation or request in what respect construction of such project would be in conflict with the purpose of the Act and would affect the component and the values to be protected by it under this Act."

Stillaguamish Basin



STILLAGUAMISH BASIN

DESCRIPTION OF BASIN

GENERAL

The Stillaguamish Basin comprises 690 square miles of land and fresh water and 6 square miles of salt water with 15 miles of shoreline. About one-third of the Basin is in Skagit County and two-thirds in Snohomish County. The Stillaguamish River is formed at Arlington from the junction of its principal tributaries, the North and South Forks. The drainage areas of these tributaries are 284 and 255 square miles, respectively. The total Basin drains into Port Susan via a major distributary, Hat Slough, and a minor distributary, South Pass. Another minor distributary, West Pass, drains into Skagit Bay. An additional small area drains into Skagit Bay through Douglas Slough and several drainage ditches.

Of the eleven basins in the Puget Sound Area, the Stillaguamish ranks ninth in land area and fifth in runoff with an average of 2,940,000 acre-feet flowing into salt water annually. The average annual runoffs from the North and South Forks are 1,358,000 and 1,323,000 acre-feet, respectively.

The orographic lifting of moist maritime air on the windward foothill slopes and higher elevations of the Cascade Mountains results in average annual precipitation ranging from about 30 inches at the mouth of the Stillaguamish River to in excess of 100 inches on the North Fork, and 160 inches at the head of the South Fork. Approximately 50 percent of the annual precipitation falls during the four months of October through January, and 75 percent from October through March. Average winter snowfall ranges from less than 10 inches near the mouth of the Stillaguamish River to approximately 400 inches at the higher elevations.

Streamflow characteristics and other data related to hydrology of the Basin are discussed in detail in Appendix III, Hydrology and Natural Environment. The physiographic characteristics of the Basin are discussed in more detail in Appendix V, Water-Related Land Resources.

PRESENT SITUATION

Local Economy

About 18,000 people reside in the Stillaguamish Basin. The two principal population centers are Arlington (about 2,200 population) and Stanwood (about 1,200 population). Most of the settlement has occurred in the rural areas. The eastern part of the Basin is sparsely populated due to the rugged terrain. Table 5-1 gives historical population statistics for the Basin and principal cities and towns.

TABLE 5-1. Historical population, Stillaguamish Basin

	1940	1950	1960	1967
Stillaguamish Basin	8,300	10,300	16,000	18,300
Principal cities and towns:				
Arlington	1,460	1,635	2,025	2,195
Stanwood and East Stanwood	959	1,088	1,123	1,240
Granite Falls	683	635	599	650

Source: Appendix IV, Economic Environment, Appendix V, Water-Related Land Resources.

Agriculture is the most important industry. Logging, the manufacture of wood products and processing of agricultural products are the principal employers of nonagricultural workers.

Land Use

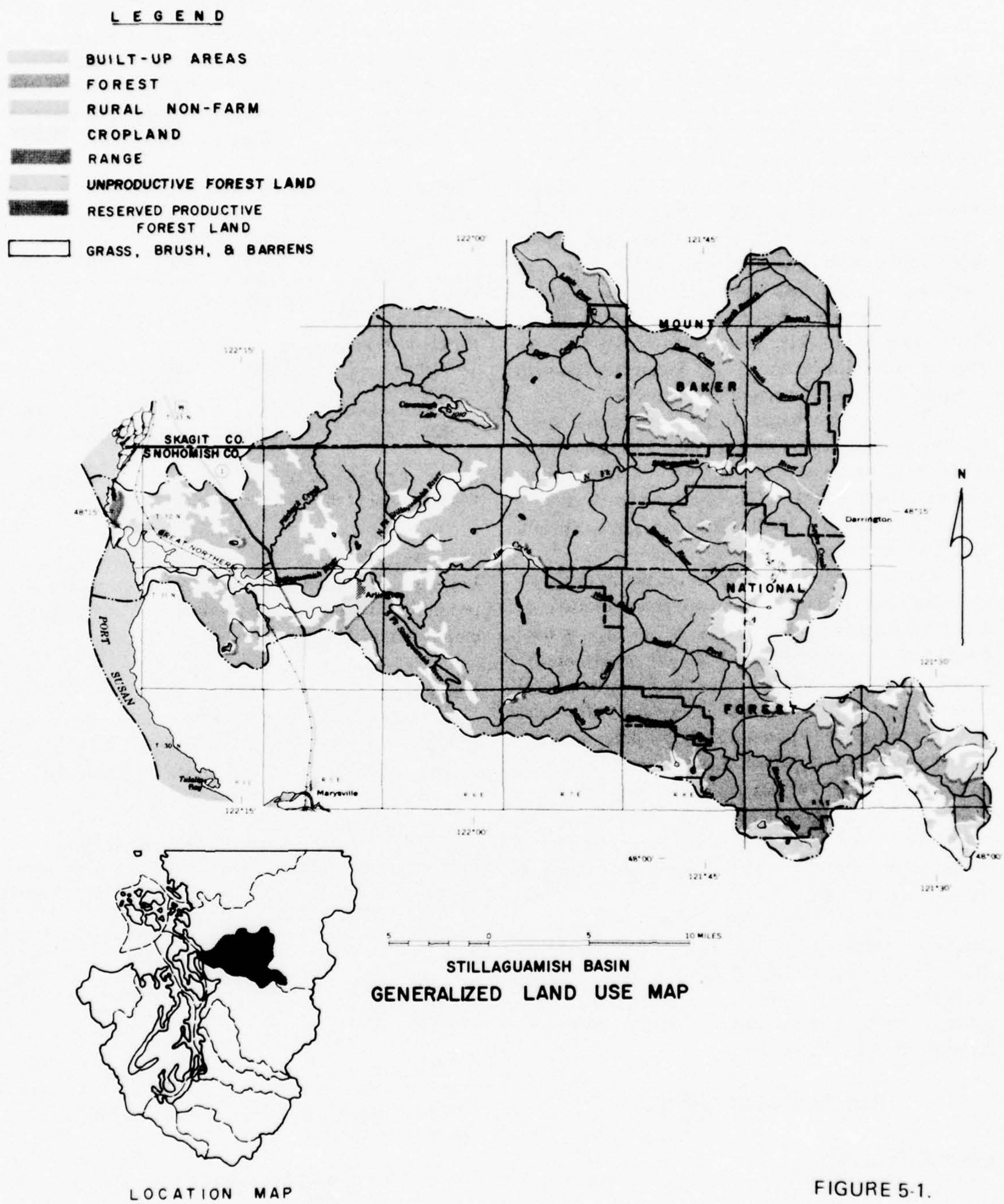
Within the Stillaguamish Basin there are 433,600 acres of land. The present land use is summarized in Table 5-2 and shown on Figure 5-1.

TABLE 5-2. Present land use, Stillaguamish Basin

Land Use	Acres	Percent
Forest[1]	385,500	88.9
Range	1,000	.2
Cropland	34,500	8.0
Rural nonfarm	5,900	1.4
Intensive	6,700	1.5
Total	433,600	100.0

[1] Includes alpine and other nonforested lands normally associated with forest.

Source: Appendix V, Water-Related Land Resources.



STILLAGUAMISH BASIN
GENERALIZED LAND USE MAP

FIGURE 5-1.

Forests are the largest classification, comprising 89 percent of the total area. Agriculture accounts for 8 percent of the land, most of which lies on the fertile Stillaguamish flood plain and adjoining nearly level to rolling glacial terraces. About 83 percent of the agricultural lands are in forage production (hay, silage and pasture) uses to support dairy and livestock industries. The remaining 17 percent of the agricultural lands are used primarily for production of berries, vegetables, canning peas, sweet corn, flower bulbs, vegetable seeds and specialty crops. With increased population demands the land use is shifting from milk and dairy products to increased acreages of vegetables and specialty crops.

The intensive land use areas are generally located within or near the communities in the western one-third of the Basin where 95 percent of the people live. The intensive land uses consist of residential areas, commercial development, public and semi-public uses and reserved open space. The intensive land use is tabulated by acres in Appendix V, Water-Related Land Resources as follows: railroads 500, roadways 4,000, airports 500, and urban (built-up) 2,000 for a total of about 7,000 acres.

Intensive development is associated with the Everett-Seattle-Tacoma metropolitan area. Employment opportunities are primarily in the Seattle-Everett areas. However, logging, the manufacture of wood products and processing of agricultural products continue to be important local employers. Land ownership is shown in Table 5-3.

TABLE 5-3. Land ownership, Stillaguamish Basin

Ownership	Percent
Private	31.9
Private corporate	11.0
Federal	40.2
State	16.4
Local government	0.5
Total	100.0

Source: Appendix V, Water-Related Land Resources.

PROJECTED ECONOMY AND LAND USE

Local Economy

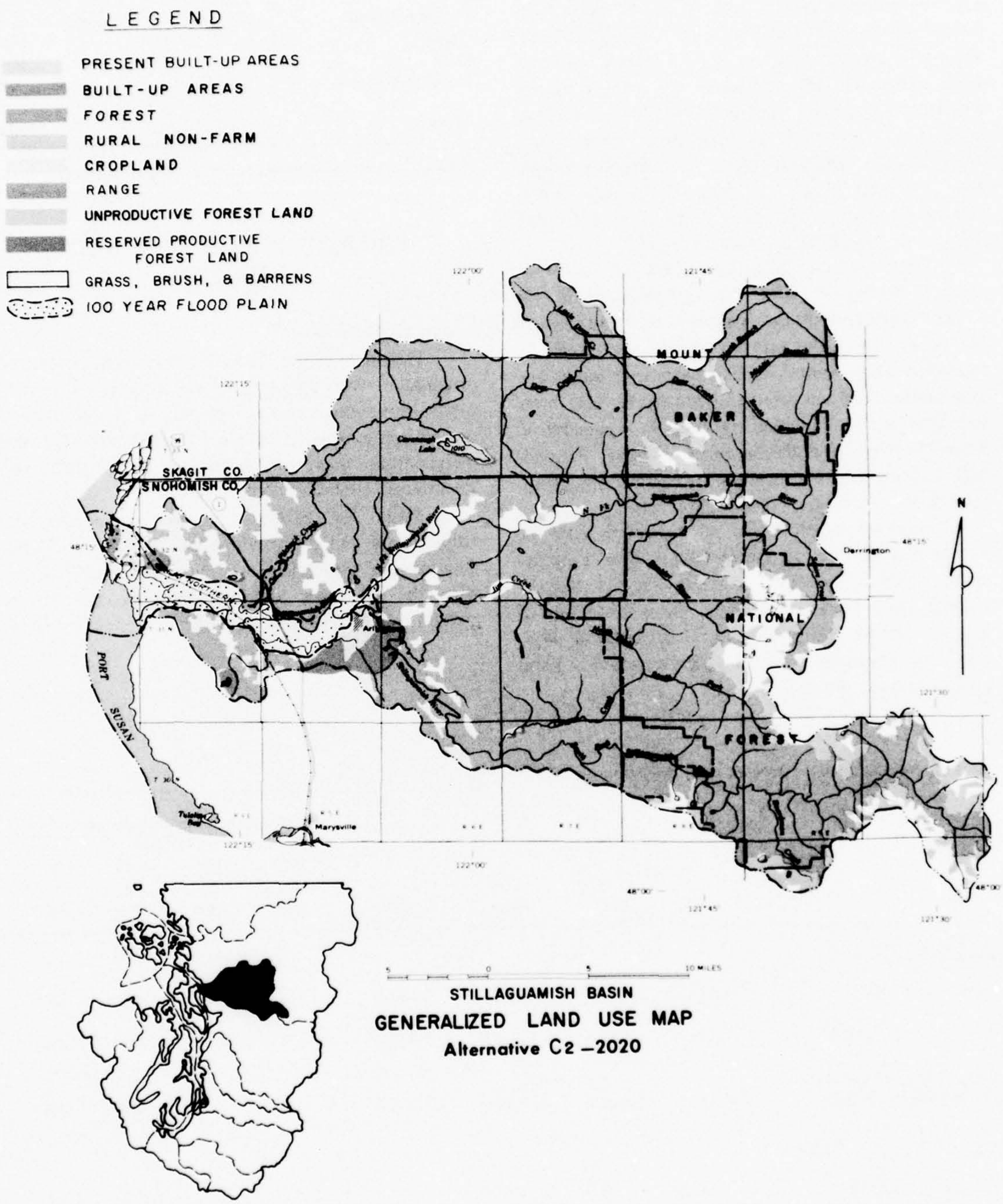
Historically the economy has been primarily oriented toward agriculture and timber with small urban communities as the centers of activity. With the future expansion of the Everett-Seattle-Tacoma metropolitan area, this Basin has the potential of becoming a suburban community.

Table 5-4 shows the forecast population, employment and gross regional product for the North Division and population for the Stillaguamish Basin, with the forecasts translated into average annual growth trends. The growth trends are expected to be

TABLE 5-4. Economic projections, Stillaguamish Basin

					Average Annual Growth Trends (Percent)			
	1963	1980	2000	2020	1963 to 1980	1980 to 2000	2000 to 2020	1963 to 2020
Central Division								
Population (1000's)	1,603.0	2,418.9	3,882.1	6,235.5	2.4	2.4	2.4	2.4
Employment (1000's)	579.1	873.2	1,399.8	2,248.4	2.4	2.4	2.4	2.4
Gross Regional Product (1,000,000's 1963 $)	5,172.0	10,022.0	24,569.0	62,061.0	3.9	4.6	4.7	4.4
Stillaguamish River Basin								
Population (1000's)	17.6	30.2	48.5	77.8	3.2	2.4	2.4	2.6

Source: Appendix IV, Economic Environment; Appendix V, Water-Related Land Resources.



STILLAGUAMISH BASIN
GENERALIZED LAND USE MAP
Alternative C2 –2020

FIGURE 5-2.

somewhat larger than the North Division trends and reflect the pressure on population from the Seattle-Tacoma metropolitan area.

Future Land Use

The projected land use of the Stillaguamish Basin for 2020, shown on Figure 5-2, is compared in Table 5-5 with present land use. This land use pattern, based on the construction of a cross-Sound bridge and a bridge between the mainland and southern Whidbey Island, projects for the Stillaguamish Basin an intensive land use density increase from the present 2.4 persons per acre to 6.1 persons per acre by 2020.

To support an increase in population of 4.3 times the present population by 2020, there would be a need to increase the intensively used land by about 6,000 acres to 1.9 times its present amount. The added intensive use land would come from all other categories, but primarily from forest land. Range land would reduce by about 30 percent with other categories not expected to undergo significant reductions.

TABLE 5-5. Present and projected[1] land use, Stillaguamish Basin (acres)[2]

Land Use	1967	1980	2000	2020
Forest	385,500	383,500	382,400	381,300
Range	1,000	900	800	700
Cropland	34,500	34,400	34,000	33,600
Rural nonfarm	5,900	5,800	5,600	5,300
Intensive	6,700	9,000	10,800	12,700
Total	433,600	433,600	433,600	433,600
Population	18,300	30,200	48,500	77,800
Density[3]	2.4	3.4	4.4	6.1

1 Alternative land use pattern C_2, see Puget Sound Area.

2 Figures rounded to nearest hundred.

3 Persons per intensive land use acre.

Source: Appendix V, Water-Related Land Resources.

WATER AND RELATED LAND RESOURCE NEEDS

MUNICIPAL AND INDUSTRIAL WATER SUPPLY

General

About 18,300 persons and two industries in 1965 used a total of 2.2 mgd of which surface waters supplied 0.1 mgd and ground water 2.1 mgd. Wells and springs supplied cities and communities with 0.9 mgd, serving a population of 6,140 persons. The city of Arlington obtains its water supply from two wells that have a combined maximum yield of about 2.3 mgd. The water supply for the city of Stanwood is drawn from four wells and springs that have a maximum total yield of 3.8 mgd. The community of Silvana obtains its water supply from springs. Industrial food and associated processors at Stanwood are supplied an average of 0.6 mgd from Stanwood municipal sources. An estimated 12,100 persons are supplied 0.7 mgd from about 3,500 individual rural systems. Municipal and industrial water use for the year 1965 is shown in Table 5-6.

Surface water resources are virtually undeveloped at present and nearly all water consumed in the Basin is drawn from ground water sources. Surface water of high quality represents the much greater percentage of water available.

Present and Future Needs

Total average daily water requirements are predicted to reach 16.6 mgd by the year 2020, representing an eight-fold increase over the 1965 usage.

Sufficient capacity is required for municipal and industrial systems to meet peak demands. The establishment of these peak demands is governed largely by population distribution; the trend of per capita consumption; the ratio of residential to industrial users; whether the service is metered or flat-rate; the characteristics of annual peak consecutive days of maximum demand and average monthly demand; and the Washington State fire underwriters' minimum flow requirements. Table 5-7 shows the projected municipal and industrial water needs for the years 1980, 2000, and 2020.

TABLE 5-6. Municipal and industrial water use, 1965, Stillaguamish Basin

System	Estimated Population Served	Surface Water Usage (mgd) Average Daily	Maximum Monthly	Maximum Daily	Ground Water Usage (mgd) Average Daily	Maximum Monthly	Maximum Daily
MUNICIPAL USE							
Arlington	2,190	--	--	--	0.35	0.55	0.73
Stanwood	2,000	--	--	--	0.40	0.70	0.80
Granite Falls	600	--	--	--	0.05	0.07	0.10
Other rural community systems	2,010	0.05	0.08	0.10	0.12	0.18	0.24
Subtotal	6,800	0.05	0.08	0.10	0.92	1.50	1.87
RURAL-INDIVIDUAL USE	12,100	0.07	0.10	0.13	0.60	0.85	1.21
INDUSTRIAL USE							
Municipally supplied:							
Stanwood							
Food and kindred	--	--	--	--	0.55	4.00	5.00
Total	18,900	0.12	0.18	0.23	2.07	6.35	8.08

Source: Appendix VI, Municipal and Industrial Water Supply.

TABLE 5-7. Projected municipal and industrial water needs, Stillaguamish Basin

Year	Use	Total (Average Daily M.G.D.)	Total (1000's Acre-Feet Annually)	Net Needs[1] (M.G.D.)	Net Needs[1] (1000's Acre-Feet)
1965	Municipal	1.0	1.1		
	Industrial	0.5	0.6		
	Rural-Individual	0.7	0.8		
	Total	2.2	2.5		
1980	Municipal	2.4	2.7		
	Industrial	0.8	0.9		
	Rural-Individual	1.3	1.5		
	Total	4.5	5.1	2.3	2.6
2000	Municipal	5.0	5.6		
	Industrial	1.7	1.9		
	Rural-Individual	2.2	2.5		
	Total	8.9	10.0	6.7	7.5
2020	Municipal	9.8	11.0		
	Industrial	3.0	3.4		
	Rural-Individual	3.8	4.3		
	Total	16.6	18.7	14.4	16.2

[1] Cumulative total above 1965 use.

Source: Appendix VI, Municipal and Industrial Water Supply.

IRRIGATION

General

About 2,500 acres of land are presently being irrigated in the Stillaguamish River Basin. These lands are located in the lowlands along the Stillaguamish River and in the hilly areas west of Arlington. Topography of much of the irrigated land is nearly level to slightly undulating and irrigation is accomplished predominantly by sprinkler application. Most of the potentially irrigable lands are located near the Stillaguamish River or in areas with good ground water supplies.

The irrigated lands are served by diversions from the Stillaguamish River and its tributaries and by utilization of ground water. About 70 percent of the land area is served from surface sources and 30 percent from ground water sources. Present annual water consumption is estimated to be 4,200 acre-feet.

Present and Future Needs

Arable lands in the Stillaguamish Basin total about 12,000 acres and are located almost entirely along the alluvial Stillaguamish River bottom. About 10,500 acres of these lands are expected to be under irrigation by the year 2020. Present and future irrigation water needs are shown in Table 5-8.

TABLE 5-8. Irrigation present status and projected needs, Stillaguamish Basin

Year	New Irrigation (acres)	Total Irrigation (acres)	Total Annual Diversion (ac. ft.)	Net Needs[1] (ac. ft.)
1966		2,500	4,800	--
1980	4,000	6,500	12,500	7,700
2000	4,000	10,500	20,200	15,400
2020	--	10,500	20,200	15,400

[1] Cumulative annual diversion above 1966 use.

Source: Appendix VII, Irrigation.

The monthly distribution of the irrigation requirements are shown as a percent of the annual demand:

June	18%	August	30%
July	37%	September	15%
		Total	100%

WATER QUALITY CONTROL

General

Waters flowing into the Stillaguamish River are of good quality. A review of several water quality indicators shows that the water is soft, low in dissolved solids, and high in dissolved oxygen concentrations. Bacteriological measurements of the water show high coliform counts, occasionally occurring below points of waste disposal. Maximum stream temperatures are relatively low above Arlington. Below Arlington the river warms and the maximum temperature on the main stream near Silvana has reached 82°F. Streamborne sediment in the Basin is minimal even though precipitation in the higher elevations is excessive. The well drained glacial till and outwash materials protected by a heavy cover of vegetation are not easily eroded. Sediment from clay slides, has at times, been detrimental to water quality.

Nonseasonal waste discharges to fresh waters in the Basin are occurring from cities and industries at a rate equivalent to those from a population of 2,200 persons. An additional 221,000 PE occurs daily during the food processing season. Table 5-9 outlines the principal sources of waste discharge to fresh water in the Basin.

Nonseasonal untreated wastes are reduced from 5,600 PE to 2,200 PE by treatment and seasonal untreated wastes are reduced from 335,000 PE to 221,000 PE. No direct discharges are made to marine waters.

Present and Future Needs

There are few water quality problems in the Basin. The most significant deficiency exists on the lower Stillaguamish River below Stanwood where large industrial organic wasteloads deplete the dissolved oxygen content of the stream below acceptable levels. Mud and clay slides, one on each fork of the river, continually cause excessive water discoloration and heavy siltation of the downstream reaches. The periodic high temperature levels in the lower river reaches is also an adverse natural condition.

The major future waste source is expected to continue to be the food processing industry. Municipalities and recreation developments would be the other two significant waste sources but together would only contribute about 5 percent of the projected total in the year 2020. Stanwood is assumed to remain the major food processing center.

TABLE 5-9. Summary of municipal and industrial wastes, Stillaguamish Basin, 1965

Receiving Water	Estimated Population Served	Nonseasonal Untreated Waste PE	Seasonal Untreated Waste PE	Treatment	Nonseasonal Waste Discharge PE	Seasonal Waste Discharge PE
Stillaguamish River						
Arlington	2,000	2,000	--	Primary	1,400	--
Stanwood	1,100	3,600	--	Lagoon	800	--
Food processing	--	--	150,000	Stanwood	--	36,000
Food processing	--	--	185,000	None	--	185,000
TOTAL	3,100	5,600	335,000		2,200	221,000

Source: Appendix XIII, Water Quality Control.

The present and projected wasteloads are shown in Table 5-10.

TABLE 5-10. Present and projected raw wasteloadings, Stillaguamish Basin (1000's PE)

Year	Municipal	Industrial	Recreational	Total	Net Needs[1]
1965	6	335	8	349	233
1980	15	503	12	530	414
2000	30	1,005	22	1,057	941
2020	54	1,843	40	1,937	1,821

[1] Cumulative raw wasteload requiring treatment above that receiving treatment in 1965.

Source: Appendix XIII, Water Quality Control.

Because future major wasteloads are projected to be essentially of the same nature and located in the same places, treatment requirements can largely be met through expansion of the facilities required to meet the present needs. Small communities that grow beyond several hundred population would also have to meet their waste handling needs with adequate treatment facilities.

Recreation growth can be expected to result in resorts and cabins along the rivers and streams of the upper Basin. Waste collection and treatment schemes designed for this situation would be required in the future.

Assuming the above treatment methods are adopted the Stillaguamish River below Arlington must have minimum flows of 20 cfs by 1980, 30 cfs by 2000 and 40 cfs by 2020 to assimilate the projected residual wastes from that area. Presuming a 1980 suburban population of 20,000 people just below Arlington, about 70 cfs would be needed in this area following adequate treatment. If the residual industrial (food processing) wastes at Stanwood are discharged into the stream, several hundred cfs of flow would be required to maintain dissolved oxygen standards. By utilizing a land disposal method for industrial wastes the minimum flow requirement for municipal wastes can be reduced to 20 cfs for 1980 and 30 cfs in 2000.

NAVIGATION

General

There are no developed harbors in this Basin. The Stillaguamish River is navigable only on the high tides. A project on the Stillaguamish River authorizes dredging of a channel 75 feet wide with a bottom at mean lower low water. No construction work has been done and the project is "inactive" because of a silt problem.

The only significant waterborne traffic in this Basin is the movement of rafted logs on the Stillaguamish River which reached a maximum of 25,384 tons in 1963. There are no significant water terminals or water transport-oriented industries in this Basin. No significant small boat facilities exist along the salt water shoreline and only minor facilities exist on the river and its tributaries.

Major silt loads occur on the Stillaguamish and

have resulted in practically closing off the old river channel. Local interests desire a 12-foot channel below Stanwood by way of South Pass but the silting problem makes this project impractical. Development of several thousand acres of tideflats at the head of Port Susan for industry and port facilities might be a possibility.

Present and Future Needs

Future projected needs for wet moorages are shown in Table 5-11. No significant amount of water transport traffic is forecast for the future.

TABLE 5-11. Projected pleasure boating needs, Stillaguamish Basin

Year	Small Boat Wet Moorages Total	Small Boat Wet Moorages Net Needs
1966	250	250
1980	400	400
2000	770	770
2020	1,500	1,500

Source: Appendix VIII, Navigation.

POWER

General

There are no hydroelectric or thermal power generating plants in the Stillaguamish Basin. Electrical energy presently utilized is generated outside of the Basin.

Present and Future Needs

The electrical energy needs are expected to grow even faster than the rate of population expansion. Additional power generation and transmission facilities would be required to meet these needs.

There are a number of sites in the Basin having a potential for hydroelectric power development. These include pumped-storage sites as well as multiple storage sites where power could be provided as an additional project purpose.

A number of thermal nuclear power plants would be required in addition to power supplied from the Pacific Northwest regional system to meet the future needs of Puget Sound Area. The possibility of a nuclear-fired power plant being located in the Stillaguamish Basin is unknown at this time. Further location and environmental studies must be conducted before specific sites can be selected. Power needs are discussed further in the Area portion of this Appendix.

FLOOD CONTROL

General

The flood plain of the Stillaguamish River contains about 12,600 acres of fertile land below Arlington and 900 acres of pastureland upstream of Arlington on the North and South Forks. Some major industries related to agriculture and forestry products are located within the flood plain.

The greater part of the flood damage is to land and crops, related buildings and equipment, and highways. Average annual flood damages are estimated to be $256,000 based on 1960 price level and conditions. Damages that would occur from a flood with an estimated recurrence interval of 100 years is estimated to be $3,355,000.

Existing flood control measures include a flood forecasting and warning system, levees, bank protection, channel improvements, and flood plain zoning regulations adopted by Snohomish County on April 15, 1968. Levees have been constructed below Silvana by landowners to prevent flooding by high tides. These levees also prevent inundation from riverflows with an approximate recurrence interval of once in three years. During extremely high tides, some of these levees are overtopped. Levees near Stanwood on both the Stillaguamish River and South Pass were overtopped by an extremely high tide in December 1967 and approximately 620 acres were flooded with salt water.

The 12,600-acre flood plain below Arlington is subject to frequent flooding. There are no storage reservoirs to regulate streamflow and discharges have varied widely from a peak of 65,000 cfs in the flood season to less than 200 cfs in late summer.

Table 5-12 lists the peak discharges and recurrence intervals of major floods and projected 50 and 100-year floods in the Stillaguamish Basin. Estimated flood damages are based on 1966 prices and conditions.

TABLE 5-12. Major floods and estimated damages, Stillaguamish Basin

	Peak Discharge of Stillaguamish R. at Arlington (cfs)	Average Recurrence Interval (years)	Current Estimated Damages
Feb. 1932	65,000	19	$ 890,000
Feb. 1951	61,000	11	705,000
Nov. 1959	59,600	9	655,000
Estimated	82,000	50	2,180,000
Estimated	93,000	100	3,355,000

Source: Appendix XII, Flood Control.

Present and Future Needs

Due to the proximity of the Basin to the Seattle-Everett metropolitan area, a need for more intensive agricultural use of the flood plain lands to supply food needs to the increasing populations is developing. Increased encroachment from urban expansion into the flood plain can be expected around the existing communities. In the upper reaches of the river increased recreational use including summer recreation homes can be expected.

Additional flood protection is needed to reduce the present average annual flood damage of $256,000 that now occurs to croplands, buildings, equipment and transportation facilities. The existing level of protection of three to five years for agricultural lands should be increased to provide adequate protection for intensive agriculture. A 100-year level of protection should be provided to existing and future developments in the city of Stanwood. The entire Stillaguamish flood plain should be managed to ensure that land use is compatible with the degree of flood protection provided. Flood damage reduction needs are shown in Table 5-13.

TABLE 5-13. Projected flood damage reduction needs,[1] Stillaguamish Basin

Year	Total ($1000)	Net Needs[2] ($1000)
1966	256	256
1980	380	380
2000	690	690
2020	1,310	1,310

[1] Based on 1966 prices and conditions.

[2] Flood damages which would occur without additional measures.

Source: Appendix XII, Flood Control.

WATERSHED MANAGEMENT

General

Watershed management is primarily concerned with treatment measures for floodwater damage reduction and for water management, with protection and rehabilitation of watershed lands regardless of use. Implementation of one measure may be less effective without application of one or more other measures to the same area.

The need in the Stillaguamish Basin is for implementation of integrated programs and projects for flood prevention, drainage, erosion prevention, land treatment and rehabilitation, and water management on forest, agricultural and urban lands. The implementation of integrated programs and projects would meet the primary objectives and enhance water quality improvement, municipal and industrial water, fish and wildlife habitat, recreation and the Basin's general environment.

Present and Future Needs

The needs for watershed management are complex and two or more practices and measures may be required on the same area of land. Many measures and treatments become involved in integrated programs and projects. Broad needs are discussed in the Area presentation. The watershed management needs for the Basin are tabulated in *Table 5-14*.

TABLE 5-14. Total watershed management needs, Stillaguamish Basin

Year	Flood Prevention[1] (acres)	Watershed Protection and Rehabilitation (acres)	Water Management: Agricultural (acres)	Water Management: Urban (acres)
1980	24,500	433,600	13,500	12,600
2000	24,500	433,600	22,600	12,600
2020	24,500	433,600	30,100	13,000

[1] Includes flooding on main streams.

Source: Appendix XIV, Watershed Management.

RECREATION

General

Water-based recreation opportunities are not extensive in the Stillaguamish Basin. The shoreline along Puget Sound is restricted to tideflat areas in the

upper reaches of Port Susan and Skagit Bay. Small lakes are numerous in the mountain areas but the only large lake is Lake Cavanaugh. Most water-based recreation is concentrated along the streams and rivers with the South Fork of the Stillaguamish having the most outstanding potential. Other recreational attractions include the high mountain area in the eastern half of the Basin. This area covers some 25,000 acres of alpine or subalpine terrain and supports a large ski development on Mount Pilchuck.

In 1964 there were 35 publicly-administered outdoor recreation areas within the Basin. Sixteen of these areas were administered by the Forest Service, 14 by the State and 5 by county and cities. Of the 249,177 acres of land classified available for public visitation, 172,302 are within National Forests. In 1964 the Forest Service reported 311,800 recreation visits on these lands.

Potential for recreation development along the salt water shoreline is very limited due to extensive tidal flats and adjacent wet lands. The shoreline of the Stillaguamish River and some of the smaller rivers and creeks are well suited for site development.

Present and Future Needs

The present and future demand for water-related outdoor recreation in the Stillaguamish Basin, expressed in recreation days, is shown in Table 5-15.

TABLE 5-15. Present and projected water-related recreation demand, Stillaguamish Basin (1000's recreation days)

Year	Total	Net Needs[1]
1960	830	470
1980	1,600	1,240
2000	3,000	2,640
2020	5,500	5,140

[1] Cumulative needs above 360,000 recreation days satisfied by facilities existing in 1960.

Source: Appendix X, Recreation.

The existing supply of developed lands was inadequate to satisfy 1960 picnicking and camping demands. Only 360,000 of the 830,000 user-day demand in 1960 were satisfied. Beaches are available to satisfy swimming demands past the year 2000, but there is an existing deficiency of swimming pools.

In addition to these needs, urban parks, scenic routes, waterfront access, recreation rivers, special interest areas, interpretive facilities, open spaces and beaches and trails for activities other than swimming and hiking are necessary to satisfy the environmental needs of the people.

FISH AND WILDLIFE

General

Anadromous fish inhabiting the Stillaguamish River system are chinook, coho, pink and chum salmon; and steelhead and searun cutthroat trout. These fish migrate, spawn and rear in over 100 miles of mainstream river including both forks, plus an additional 110 miles of accessible tributaries. Fish access was extended to the upper South Fork when fish passage facilities were completed in 1954 at Granite Falls. The fish production from the Stillaguamish Basin is a very important part of the total production for the Puget Sound Area commercial and sport fisheries.

Resident fish spawn and rear in most of the stream and lake waters. Resident species include cutthroat trout, brook trout, Dolly Varden and whitefish in most of the streams. Kokanee salmon have been successfully introduced in Cavanaugh Lake.

Fish production varies considerably over the Basin and is considerably lower in the South Fork drainage than in either the North Fork or main river drainages. Limiting factors to fish production include flooding, low flows, unstable soils, barriers, limited spawning and rearing areas, water quality, and water temperatures.

The estuary and marine waters of Port Susan, from Stanwood to Tulalip Bay on the mainland, comprise the Stillaguamish Basin marine shellfish habitat. Fresh water from both the Stillaguamish and Snohomish Rivers have combined influences on the shellfish production in this area. The major limiting element affecting the tidelands and marine environment is pollution, both municipal and industrial.

The Basin ranks high in the production of forest game species and produces significant numbers of fur animals and waterfowl. Big game animals include blacktail deer, black bear, mountain goat, and mountain lion. Numerous shallow lakes, beaver ponds, and diked sloughs and ditches with abundant emergent vegetation provide an excellent habitat for a high waterfowl and fur animal production.

Present and Future Needs

There is a need to retain and expand fishing opportunities for trout, steelhead, salmon and other species in the Stillaguamish Basin. Similarly there is a need to provide opportunities for hunting commensurate with population growth. The projected fishing and hunting needs for the Basin are shown in Table 5-16.

TABLE 5-16. Fish and wildlife, sport and commercial needs, Stillaguamish Basin

	Unit	1965 Total	1980 Total	1980 Net[1]	2000 Total	2000 Net[1]	2020 Total	2020 Net[1]
Sport Fishing								
Salmon	1000 User-Days	6	10	4	19	13	32	26
Game Fish	1000 User-Days	337	563	226	886	549	1,417	1,080
Marine Fish	1000 User-Days	0	0	0	0	0	0	0
Shellfish	1000 User-Days	0	0	0	0	0	1	1
Total		343	573	230	905	562	1,450	1,107
Hunting	1000 User-Days	54	105	51	170	116	209	155
Commercial Fishing	1000 Pounds	--	3,133	--	5,290	--	7,366	--

[1] Cumulative need above 1965 activity.

Source: Appendix XI, Fish and Wildlife.

COMPREHENSIVE PLAN

BASIS OF PLANNING

Desires of Local People

Expressions by local interests relative to basins in Snohomish County were invited at a public hearing held at Everett on October 22, 1964. Other meetings were held with interested groups. The need for flood control and other improvements in the Stillaguamish Basin was recognized, but a strong desire was also expressed for minimizing changes which would affect the existing river conditions (see Appendix I, Digest of Public Hearings).

Summary of Basin Needs

The needs of the Stillaguamish Basin for 1980, 2000 and 2020 are summarized in Table 5-17.

TABLE 5-17. Summary of needs, Stillaguamish Basin

Feature	Units	Cumulative Net Needs[3] 1980	2000	2020
M&I Water Supply	mgd	2.3	6.7	14.4[1]
	1000 Acre-Feet	(2.6)	(7.5)	(16.2)[1]
Irrigation	1000 Acre-Feet	7.7	15.4	15.4
Water Quality Control				
Waste	1000 Population Equivalents	414	941	1,821
Flow[4]	cfs	20	30	40
Navigation				
Commercial	1000 Short Tons	0	0	0
Pleasure Boats	Wet Moorages	400	770	1,500
Power[2]				
Flood Control	$1000 Damage Reduction	380	690	1,310
Watershed Management				
Flood Prevention	1000 Acres	24.5	24.5	24.5
Watershed Protection and Rehabilitation	1000 Acres	433.6	433.6	433.6
Water Management				
Agricultural	1000 Acres	13.5	22.6	30.1
Urban	1000 Acres	12.6	12.6	13.0
Recreation	1000 User-Days	1,240	2,640	5,140
Fish and Wildlife				
Sport				
Fishing	1000 User-Days	230	562	1,107
Hunting	1000 User-Days	51	116	155
Commercial Fishing	1000 Pounds	3,133	5,290	7,366

[1] In addition, an estimated 3.9 mgd (4,300 acre-feet annually) would be needed (from the Stillaguamish River) to meet the Camano Island demand, after the year 2000.

[2] Power needs were projected for the Puget Sound Area only.

[3] See Water and Related-Land Resource Needs for derivation of net needs.

[4] Stillaguamish River.

General Planning

A wide range of alternative nonstorage and management opportunities were viewed in the Stillaguamish Basin. These included diversion structures, direct river pumping and treatment, desalinization, inter-basin water transfer, further ground water utilization, and improved water yields through various watershed management practices to satisfy water supply needs of municipalities and industry, irrigated farming, water quality preservation and enhancement, and fish use. Levees, channelization, diversion, flood plain evacuation, bank protection, and improved land use management practices were considered as possible means of meeting flood control and watershed management needs. Opportunities considered for satisfaction of water quality needs were sewage collection and treatment facilities and minimum flows available to assimilate residual waste-

loadings. The water and related land resource was examined in terms of projected land use pattern C_2 (see Projected Land Use). Land needs of navigation, power, recreation, and fish and wildlife, were considered within this land use context.

There are storage sites on a number of Stillaguamish Basin rivers which could provide opportunities for water control. With storage greater utilization of the resource would allow satisfaction of water supply needs and minimum streamflow requirements for anadromous and resident fish. Approximately 150,000 acre-feet of storage is required to provide 100-year protection in the Basin. There are three potential sites on the South Fork and one on the North Fork which could develop sufficient quantities of water to meet projected water supply needs even during a year of extreme low runoff without reducing streamflows below historical minimums during critical periods for fish. For further information on minimum streamflows for fish see the Area discussion on Fish and Wildlife.

Alternative objectives were considered in developing the Comprehensive Plan. The objectives represented both ends of the spectrum of interests, i.e., economic efficiency and environmental quality as discussed in the Puget Sound Area section of this Appendix. The alternative elements considered in plan formulation are described under Alternative Elements.

The single-purpose Appendices, V through XIV, provided a wide array of solutions. Necessary adjustments were made to these solutions in the formulation of comprehensive plans for the Basin. These adjustments consisted of:

(a) Flood control storage sites, shown in Appendix XII, on the North and South Forks of the Stillaguamish River were not used. Flood plain management and levees were considered to be the better solutions for the long-range period with these rivers left in their free-flowing state.

(b) Fish and wildlife measures contained in Appendix XI were modified with expansion and/or construction of additional artificial salmon propagation facilities planned in lieu of storage projects required for flood control and low flow augmentation. Cross-sectional stream surveys planned for the early action period to determine the minimum and optimum streamflows required for fish production may show that further consideration should be given to storage development.

SUMMARY OF PLAN

Early Action, 1970-1980

During this period ground water resources would continue to supply Arlington, Stanwood, and rural communities. Minor use of surface waters for rural and individual systems is expected.

About 4,000 acres of cropland would be placed under irrigation with water supplied by individual farmers from both surface and ground sources. All development would be by individuals utilizing the most economical means available.

Compliance with Washington State water quality standards would be obtained through installation of adequate collection and treatment facilities by a number of communities and cities in the Basin. The food processing industry would provide adequate means of waste disposal either through use of municipal facilities or land disposal. A water quality surveillance program would be expanded in order to provide an adequate monitoring system with sampling stations on marine and fresh water. A comprehensive sewerage basin plan would be developed for the Basin.

No commercial navigation needs are projected for the Stillaguamish Basin. The extensive tidelands in Port Susan and the shoaled condition of the Stillaguamish River at Stanwood make development of small boat basins within the Basin impracticable under present conditions. Accordingly, small boat moorage needs of the Stillaguamish Basin would be met in the Skagit-Samish Basins.

Power needs for the Basin would be satisfied by the Northwest Regional system which is discussed under Power in the Area portion of this Appendix.

A flood control project to straighten and enlarge the Stillaguamish-Hat Slough channel below Silvana in connection with levees is planned. A levee north of Stanwood is recommended to provide protection from flooding in the Skagit Basin. These improvements would provide 100-year protection for 7,300 acres of land. Flood plain management would provide an effective means of reducing future flood damages through land use zoning of lands in the flood plain consistent with the levels of flood protection provided. Floodproofing and warning systems also would be implemented. These measures would contribute significantly to the reduction of future flood damages.

Two small watershed multiple-purpose projects are planned for implementation during this period to

achieve floodwater damage reduction and install water management measures, together with protection and rehabilitation of watershed lands. These projects contain structural measures such as stabilized channels, dikes on the Stillaguamish, and outlet control structures. Upgrading of existing facilities and more intensive application of recurring and nonrecurring land treatment practices would be required throughout the Basin. Soil and water conservation programs which offer technical assistance and financial participation would be continued.

Campgrounds, picnic areas, beaches, and boat launching ramps would be developed on existing public lands together with the acquisition of additional land and water areas to satisfy recreational needs. Additional land and water areas would be acquired along the Puget Sound shoreline to provide marine parks. About 40 recreation sites are planned for expansion or development before 1980.

Land acquisition, access easements and fish and wildlife enhancement projects would be undertaken to increase the opportunities for this form of outdoor recreation. Additional fish hatcheries would be constructed for both resident and migratory fish together with rearing ponds, spawning channels and fish passage improvements on the South Fork of the Stillaguamish River. Cross-sections of the streams would be surveyed during this period to determine the minimum and optimum streamflows required for fish production. These cross-sectional surveys may show further studies of storage sites to be warranted.

Long-Range, 1980-2020

Arlington, Stanwood and other small rural communities within the Basin would continue to develop ground water to satisfy their needs to 2020. A limited amount of surface water would be utilized by rural consumers.

An additional 4,000 acres of land would be placed under irrigation with water supplied by individual farmers from both ground and surface sources.

Existing sewage treatment and collection facilities would be expanded commensurate with the growth in population and industrial development to insure that the State water quality standards are continually met. The water quality surveillance program would be maintained.

As in the early action program, no commercial navigation needs have been projected for the Basin. Shorelands are unsuitable for small boat harbors. This need would be fulfilled in the Skagit-Samish Basins.

Power development would probably include pumped-storage at a number of the potential sites within the Basin. Oil or gas-fueled steam electric plants also may be located during this period to meet short-time peaking requirements. Development of nuclear electric generating plants may occur but specific sites have not been determined and would be dependent upon future studies that consider shoreline characteristics, nearness to major load centers and impacts on the environment.

The only additional flood control structures envisioned after 1980 would be a construction of levees to provide 25-year flood protection for 4,000 acres of land between Arlington and Silvana. Flood plain management would be continued with zoning being required to guide future development and prevent unwarranted development in the flood plain.

Six additional multiple-purpose projects would be undertaken to satisfy watershed management needs in this time period. In addition to the structural measures provided by these projects, a significant program of technical assistance, land treatment, and water management would be continued and enlarged.

Additional development of campgrounds, picnic areas, and other recreation facilities would be undertaken after 1980 at nearly 100 sites throughout the Basin, on public lands as well as private lands, with both public and private sectors participating in the providing of recreational facilities. The South and North Forks of the Stillaguamish may be included in a State system of scenic and recreational rivers for retention for public use.

Further fishing opportunities would be provided through anadromous and resident fish enhancement measures. A number of fish passage improvements are planned during the long-range period as well as additional spawning habitat development. Wildlife preservation and enhancement programs begun prior to 1980 would be continued.

Table 5-18 summarizes the Stillaguamish Basin elements of the Comprehensive Plan, showing the benefits and costs for the early action portion of the Plan, and provides a summary of investment costs by water resource functions for the entire 50-year period ending in 2020. The early action portion of the Plan

TABLE 5-18. Comprehensive Plan, Stillaguamish Basin

Feature	Items	1970-1980 Investment[1] Costs ($1000)	1970-1980 Average Annual Costs ($1000)	1970-1980 Average Annual Benefits Gross ($1000)	1970-1980 Average Annual Benefits Net ($1000)	1980-2000 Investment Costs ($1000)	2000-2020 Investment Costs ($1000)	1970-2020 Investment Costs ($1000)
Management Programs								
Water Quality Control	Monitoring, Evaluation and Control Programs	160	--	--	--	300	340	800
Flood Control	Flood Plain Management	25	--	--	--	46	46	1,117
Watershed Management	Programs	28,693	--	--	--	29,480	28,547	86,720
Fish & Wildlife	Programs	160	--	--	--	320	320	800
Total Programs		$29,038				$30,146	$29,253	$ 88,437
Nonstorage Projects								
M&I Water Supply	Ground Water Use	564	75	75[3]	0	858	1,152	2,574
Irrigation Water Supply	Ground Water Use	270	45	45[3]	0	270	0	540
	Surface Water Use	270	45	45[3]	0	270	0	540
Water Quality Control	Sewerage Treatment and Collection Facilities	1,860	127	127[3]	0	3,294	3,980	9,134
Navigation[2]		--	--	--	--	--	--	--
Power[2]		--	--	--	--	--	--	--
Flood Control	Channels and Levees	7,700	454	500	46	3,700	0	11,400
Watershed Management	Floodwater Damage Reduction, Water Management and Rehabilitation and Protection of Watershed Lands	1,645	92	288	196	5,620	1,310	8,575
Recreation	Land Acquisition, Access and Recreation Facilities	20,420	1,256	1,484	228	20,800	40,200	81,420
Fish & Wildlife	Projects	5,220	521	1,528	1,007	5,568	9,412	20,200
Total Nonstorage		$37,949	$2,615	$4,092	$1,477	$40,380	$56,054	$134,383
Total Programs and Projects		$66,987	$2,615	$4,092	$1,477	$70,526	$85,307	$222,820

1 Includes cumulative annual program costs for the period for management features and capital costs for nonstorage projects.

2 Power and Navigation facilities not included in Basin Plan.

3 Average annual benefits assumed equal to average annual costs.

includes programs amounting to $29,038,000 and projects costing $37,949,000 for a total investment of $66,987,000. Program and project investment costs for the 1980-2000 period amount to $70,526,000 and for the 2000-2020 period, $85,307,000; for a total 50-year investment of $222,820,000.

FEATURES OF COMPREHENSIVE PLAN

Municipal and Industrial Water Supply

Stanwood and Arlington are expected to provide the major portion of the Basin water supply. Most of the municipal and industrial water would be supplied from wells developed by these agencies. Surface water sources accounting for relatively insignificant part of the total water supply would be used mainly by private and small rural systems. That portion of the Comprehensive Plan dealing with municipal and industrial water supply is discussed by the following time periods:

1970-1980 During this period water consumption within the Basin is expected to double with all systems further utilizing existing sources. Ground water accounts for the great preponderance of municipal and industrial water. The only surface water being used within the Basin is by some of the small and rural communities. Arlington and Stanwood would continue to be the largest purveyors of water. The projected average daily water use for the Stillaguamish Basin, planned supply and transmission investments and average annual costs are given below:

Development	Needed by Year	1980 Average Daily Water Use (mgd)	Supply, Transmission & Treatment Investment ($1000)	Average Annual Costs: Interest & Amort.[1] ($1000)	Average Annual Costs: O&M[2] ($1000)	Average Annual Costs: Total ($1000)	Average Annual Benefits[3] ($1000)
Arlington		0.6					
Additional ground water development	1970		150				
Stanwood		1.8					
Additional ground water development	1970		36				
Additional ground water development	1975		240				
Granite Falls		0.2					
Additional ground water development	1970		36				
Small and Rural Community Systems		1.9					
Additional ground and surface water development	1970		66				
Additional ground and surface water development	1975		36				
Total		4.5	$564	$44	$31	$75	$75

[1] Interest and amortization of capital investment costs.

[2] Total incremental increase in annual operation and maintenance costs, including pumping and treatment costs.

[3] Average annual benefits assumed equal to average annual costs.

1980-2000—Arlington and Stanwood's water needs in this period would be met by further utilization of ground water supplies. Other small rural communities also would develop ground water for their use. A minor amount of surface water would be developed by rural users. A summary of projected average daily use and investment costs required by the year 2000 would be:

Development	Needed by Year	2000 Average Daily Water Use (mgd)	Supply, Transmission and Treatment Investment ($1000)
1980-2000			
Arlington		1.5	
Additional ground water development	1990		180
Stanwood		3.8	
Additional ground water development	2000		558
Granite Falls		0.4	
Additional ground water development	1990		36
Small and Rural Community Systems		3.2	
Additional ground and surface water development	1990		84
Total		8.9	$858

2000-2020—Stanwood would continue to utilize ground water sources to meet the water demand projected for this period. Arlington's supply of water is sufficient, but additional pumping capacity must be installed to meet demands. Other small rural communities would continue to rely heavily on ground water for supply. The projected average daily use and investment costs for municipal and industrial water supply, required by the year 2020, are summarized as follows:

Development	Needed by Year	2020 Average Daily Water Use (mgd)	Supply, Transmission and Treatment Investment ($1000)
2000-2020			
Arlington		2.7	
Additional water use	2020		--
Stanwood		7.6	
Additional ground water development	2015		996
Granite Falls		0.9	
Additional ground water development	2010		78
Small and Rural Community Systems		5.4	
Additional ground water development	2010		78
Total		16.6	$1,152

Irrigation

Future irrigation development is expected to take place along the fertile bottomlands or in areas with good ground water supplies. Irrigation development is anticipated to be by private means with individual farmers pumping from the river or from wells. The peak surface diversion demand of 73 cfs expected by 2020 could be met without adversely affecting other water uses.

The Comprehensive Plan provides for a net increase in the Stillaguamish Basin of 8,000 acres of irrigated land over the next 50 years for a total of about 10,500 acres in the Basin by the year 2020. Water required for the projected acreage would be equally divided between surface and ground sources.

Irrigation development as provided for in the Comprehensive Plan is discussed by the following periods.

1970-1980—Increased ground water use is planned and surface diversion with water pumped directly from the rivers would be:

1970-1980 New Irrigation Area		Diversion		Net Depletions	
Ground Water Supply (acres)	Surface Water Supply (acres)	Ground Water (acre-feet)	Surface Water (acre-feet)	Ground Water (acre-feet)	Surface Water (acre-feet)
2,000	2,000	3,700	4,000	2,700	2,700

The private investment cost to obtain the ground and surface water is estimated at $135 per acre for total investment cost of about $540,000 with total average annual charges, including interest and amortization and operation and maintenance costs of $36,000, equal to $90,000. The investment costs include provisions for on-farm sprinkler system and pumping equipment.

1980-2000–Further diversion is planned with farmers continuing to pump from wells and directly from the rivers as shown below:

1980-2000 New Irrigation Area		Diversion		Net Depletions	
Ground Water Supply (acres)	Surface Water Supply (acres)	Ground Water (acre-feet)	Surface Water (acre-feet)	Ground Water (acre-feet)	Surface Water (acre-feet)
2,000	2,000	3,700	4,000	2,700	2,700

The private investment cost for the surface and ground water diversions is estimated at $540,000.

2000-2020–No additional development is planned during this period.

Water Quality Control

Water quality control elements of the Comprehensive Plan are:

1970-1980–During this period Stanwood should enlarge its treatment facilities to accommodate existing and projected loadings. Adequate disinfection should be included in the expansion plan. The food processing industry should apply their wastes to suitable nearby lands for disposal. Arlington should provide secondary treatment which would make possible the reduction of wasteload discharged to the Stillaguamish River.

The investment costs of waste treatment and collection facilities called for by 1980 are estimated below for industry, municipalities and recreational development within the Basin. Also shown are the program costs of water quality during this period.

Water Quality Control
1970-1980

Feature	Investment Costs ($1000)	Average Annual Costs: Interest & Amortization ($1000)	Average Annual Costs: Operation & Maintenance ($1000)	Total ($1000)	Benefits[2] ($1000)
Monitoring, Evaluation and Control Program	160[1]				
Industrial Wastes					
Treatment	670	35	7	42	42
Municipal Wastes					
Treatment	370				
Sewers	370				
Subtotal	$ 740	$ 36	$ 8	$ 44	$ 47
Recreation Wastes					
Treatment	450	34	5	39	39
Total	$2,020	$105	$22	$127	$127

[1] Cumulative annual program costs for period.

[2] Average annual benefits assumed to be at least equal to average annual costs.

In the main-stem of the Stillaguamish River the minimum 1980 flow of 20 cfs, required for assimilation of residual wasteloading after secondary treatment, is available based on a review of minimum flows of record and anticipated diversions.

1980-2000 and 2000-2020—During these periods expansion by industry, new developments and growth of urban and recreation areas correspondingly would require that new sewer interception systems be installed and treatment facilities enlarged and/or constructed. Summarized below are estimated investment costs for water quality control by sectors.

The minimum 2000 and 2020 flows required for assimilation of residual wasteloading of 30 cfs and 40 cfs, respectively, are expected to be exceeded by natural flows.

Water Quality Control
1980-2020

Feature	Investment Costs ($1000) 1980-2000	2000-2020
Monitoring, Evaluation and Control Program	300[1]	340[1]
Industrial Wastes		
Treatment	830	1,380
Municipal Wastes		
Treatment	772	840
Sewers	772	840
Subtotal	$1,544	$1,680
Recreation Wastes		
Treatment	920	920
Total	$3,594	$4,320

1 *Cumulative annual program costs for the period.*

Navigation

No commercial navigation is projected in the Stillaguamish Basin through 2020. The extensive tidelands in Port Susan and the shoaled condition of the Stillaguamish River at Stanwood and its distributaries, South and West Passes, make the development of small recreational boat moorages in the Stillaguamish Basin an impracticable and uneconomical venture. Consequently, a recognized need for about 1,500 small boat moorages in the Basin would not be met through projected Basin improvements. The Skagit-Samish Basins' comprehensive plan has been adjusted to provide for the wet moorages of the Stillaguamish Basin.

Power

As previously stated, power production and distribution facilities are planned on a regional basis. The power needs of the Stillaguamish Basin would be met by facilities in the Puget Sound Area or by importation.

Proposed development of any plant would require that possible adverse impacts on the environment be considered and the means provided to lessen these impacts or mitigate their effects when specific project studies are undertaken. For additional discussion of thermal-power generation, see the Puget Sound Area.

Flood Control

The Comprehensive Plan provides for a reduction of flood damages in the Stillaguamish Basin, the majority of which occur below the community of Arlington. Flood protection objectives for the Basin are generally met by the elements proposed in this Plan. These objectives have been defined in terms of flood frequencies, with industrial and urban lands within the Basin recommended for 100-year level of flood protection, agricultural lands requiring at least 25-year level of protection, and lands along the flood plain to be used for parks, golf courses, and general recreation requiring a level of flood protection of 10 to 15 years.

Included in the Plan is provision for implementation of flood plain management measures such as floodproofing, flood plain zoning, or other positive means of land use control. Sufficient lands are considered available within the Basin to preclude the necessity of intensive development in the flood plain; however, without flood plain zoning, structural measures may be needed beyond those provided. Uncontrolled encroachments on the flood plain by residential and industrial developments would require expensive structural flood control measures to protect these high value investments.

That portion of the Comprehensive Plan dealing with flood control is:

1970-1980—A flood control project is planned to straighten and enlarge the Stillaguamish from Hat Slough Channel below Silvana. Construction of levees to carry a 100-year flood with suitable freeboard is proposed as part of this project. The project would include a controlled entrance to the Stillaguamish River where it leaves Hat Slough to assure continual flows for water quality purposes during the dry season in the channel near Stanwood. The entrance would also control flood flows in the Stillaguamish River channel to the withinband capacity of the channel. This project would result in extensive adjustments to the streambed and could adversely affect fish habitat. Any adverse impacts would require mitigation as part of the project cost.

The Stillaguamish River flood plain merges with the Skagit River flood plain north of Stanwood. Skagit River levees now protect against 3 to 15-year floods. With improvements proposed prior to 1980 for the Skagit-Samish Basins, 35-year flood protection would be obtained against Skagit River flooding. Thus, to assure 100-year protection for Stanwood, the Stillaguamish Basin project would include a levee across the flood plain north of Stanwood, extending from the sea dike on Skagit Bay in an easterly direction to high ground north of Stanwood. These structural measures would provide 100-year protection for 7,300 acres of land, including about 7,000 acres of farmland and 300 acres of urban or potentially urban land at Stanwood. The tabulation below summarizes the early action flood control programs and projects for the Stillaguamish Basin.

Flood Control Element	Design Capacity (cfs)	Investment Costs ($1000)	Average Annual Costs Interest & Amortization ($1000)	Operation & Maintenance ($1000)	Total ($1000)	Benefits ($1000)
Channel and Levee Construction						
Levees and channel improvements to protect Stanwood and the flood plain upstream to Silvana	93,000	7,700	400	54	454	
Subtotal		$7,700	$400	$54	$454	$500
Flood Plain Management		25[1]				53
Total		$7,725				$553

[1] Cumulative program cost over the period.

1980-2000—During this period a flood control project would be constructed consisting of levees and channel improvements to provide 25-year protection to 4,400 acres of agricultural land between Arlington and Silvana. Pertinent data concerning this project is tabulated below.

Flood Control Projects
1980-2000

Element	Length of Levee (miles)	Investment Costs
Levees and channelization between Arlington and Silvana	11	$3,700,000

Flood plain management costs during this period are estimated at $46,000.

2000-2020—Only the flood plain management program would be implemented after the year 2000 at a cost of $46,000.

Watershed Management

Watershed management measures are described in Appendix XIV, Watershed Management, and summarized in the Puget Sound Area section of this Appendix. These measures protect the land and water resources from excessive deterioration, generally protect and enhance environmental values, and serve to increase production, as well as achieve a variety of other economic benefits. Some of the measures are relatively permanent, once installed, while others require careful maintenance to insure effectiveness.

Federal and State land administrative agencies are responsible for the installation of the measures on lands assigned to their management, while individual initiative of the owner is required for installation of practices on lands in private ownership. Various Federal agencies and the State have programs of technical and financial assistance for individuals, local organizations, and subdivisions of government, including the Skagit and Snohomish Soil and Water Conservation Districts.

The plan includes projects primarily for reduction of floodwater damage, water management, and protection and rehabilitation of watershed lands. Watershed treatment measures have been coordinated to the extent feasible with flood control and other projects of the Federal Government and the State. Other Federal and State projects furnish incentives for installation of urban water management and similar improvements, including flood control measures. The schedule of watershed management projects and programs provided for in the Comprehensive Plan is discussed by periods as follows:

1970-1980—Several projects would be initiated prior to 1980 to remedy existing floodwater and

water management problems and to develop lands toward their potential for continued use. Following are descriptions of projects in the early action plan:

Lower Stillaguamish Watershed—This watershed is located on both sides of the Stillaguamish River and extending from the mouth to and including the city of Arlington. The flood plain of the Stillaguamish downstream from Arlington is primarily agricultural. The other principal agricultural area is the high terrace area south and west of Arlington. Outside the Stillaguamish flood plain most of the area is forest land. Pilchuck Creek drainage, in particular, has extensive tree farms and Douglas-fir and western hemlock are the principal commercial species. Some of the best red alder sites anywhere are found in the lower elevations of this watershed. On the uplands of the lower watershed there are many lakes which are attractive because of their forest setting. The forest situation in this watershed has to be reviewed on the basis of many uses and intent of ownership. A study is needed to evaluate the varied conditions in this watershed in relationship to soil and water resources.

The project is designed for flood prevention of agricultural and urban areas, and water management of agricultural lands. The area contains 8,522 acres of which 5,578 acres are cropland, 1,794 acres are forest, 872 acres rural nonfarm and urban, and 278 acres are miscellaneous uses.

The works of improvement would consist of 17 miles of improved and stabilized channel, three outlet structures consisting of floodgates and pumps, and 1 mile of new and reconstructed dike.

Installation cost is estimated to be $980,000, of which the Federal share is $671,000, and the local share is $309,000. Average annual costs, including $8,000 for operation and maintenance is estimated at $54,000. Benefits from damage reduction and drainage would provide a benefit-cost ratio of 3.2 to 1. In addition to these structural measures, it would be possible for local interests to install necessary land treatment measures for erosion control and flood management, costing approximately $400,365, drainage measures expected to cost $1,177,170, and forest protection and management practices costing $37,477, for a total of $1,615,012. The total cost of installing the structural measures and the land treatment measures is $2,595,000.

Church Creek Watershed—This watershed is located in northwest Snohomish County and includes the city of Stanwood. The stream drains into both Skagit Bay and Port Susan Sound. The lower portion of the watershed can be, and occasionally is, flooded by either the Skagit River or the Stillaguamish River in addition to flooding from heavy precipitation falling within the area. Flooding and drainage are also problems on the uplands.

The upland area is over 50 percent forest land in scattered tracts. Many of these have been logged, relogged, and cleared of wood until only a stand of native brush remains. The principal species are mixed stands of Douglas-fir and red alder, with some western hemlock, western red cedar, and big leaf maple. This upland country offers the best homesites and where wood fiber is not the main interest to the owner, measures should be advocated which improve the landscape and safeguard the water and wildlife resources.

The project is designed for flood prevention of agricultural and urban areas, and drainage of agricultural lands. The area contains 8,060 acres of which 4,431 acres are cropland, 1,706 acres are forest, 1,467 acres rural nonfarm and urban, and 456 acres miscellaneous uses.

The works of improvement would consist of 8 miles of improved and stabilized channel, three outlet structures consisting of floodgates and pumps, and 1 mile of new and reconstructed dike.

Installation cost is estimated to be $665,000, of which the Federal share is $478,000, and the local share is $187,000. Average annual costs, including $6,000 for operation and maintenance is estimated at $37,000. Benefits from damage reduction and drainage would provide a benefit-cost ratio of 3.1 to 1. In addition to these structural measures, it would be possible for local interests to install necessary land treatment measures for erosion control and flood management, costing approximately $318,038, drainage measures estimated to cost $849,494, and forest protection and management practices costing $35,639, for a total of $1,203,171. The total cost of installing the structural measures and the land treatment measures is $1,868,171.

Programs tabulated below include the complementary features to the projects discussed above and other on-farm and urban on-site practices required in the Stillaguamish Basin.

Non-Federal costs include on-going costs of development with redirection and acceleration to meet needs by time periods. Total costs are shown.

Watershed Management Practices
1970-1980

Program	Area (acres)	Costs ($1000)
Technical assistance		
and management	420,997	
Federal, regular		7,377
Federal, accelerated		58
Subtotal		$ 7,435
Installation of practices		
(non-Federal)		
State and corporate		5,325
Land treatment	245,816	3,524
Water management		
Agricultural	13,541	4,814
Urban	5,626	7,595
Subtotal		$21,258
Total		$28,693

1980-2000—The projects and programs scheduled for this period are tabulated below with estimated costs.

Watershed Management Practices
1980-2000

Program	Area (acres)	Costs ($1000)
Technical assistance		
and management	420,997	
Federal, regular		9,776
Federal, accelerated		115
Subtotal		$ 9,891
Installation of practices		
(non-Federal)		
State and corporate		7,100
Land treatment	245,816	4,339
Water management		
Agricultural	9,027	2,925
Urban	3,870	5,225
Subtotal		$19,589
Total		$29,480

Project	Area (acres)	Structural Measures Installation ($1000)
Pilchuck Creek	48,809	300
Lower Stillaguamish River	29,492	4,320
Church Creek	8,060	1,000
Total	86,361	$ 5,620

2000-2020—The projects and programs recommended for implementation during this period are shown in the following tabulation:

Watershed Management Practices
2000-2020

Program	Area (acres)	Costs ($1000)
Technical assistance		
and management	420,660	
Federal, regular		7,993
Federal, accelerated		115
Subtotal		$ 8,108
Installation of practices (non-Federal)		
State and corporate		7,100
Land treatment	245,479	4,338
Water management		
Agricultural	13,330	4,315
Urban	3,471	4,686
Subtotal		$20,439
Total		$28,547

Project	Area (acres)	Structural Measures Installation ($1000)
North Fork		
Stillaguamish	180,594	860
South Fork		
Stillaguamish	128,843	350
Jim Creek	29,307	100
Total	338,744	$ 1,310

Recreation

Water-based recreation opportunities are few by comparison with other Puget Sound basins. Frontage on Puget Sound itself is restricted to tideflat areas in the upper reaches of Port Susan and Skagit Bay. While small lakes are numerous in the mountain areas, the only large lake is Lake Cavanaugh. Most water-based recreation is concentrated along the streams and rivers. The South Fork of the Stillaguamish is the most outstanding. Other recreational attractions include the high mountain area in the eastern half of the Basin. This area covers some 25,000 acres of alpine or subalpine terrain and supports a ski development on Mount Pilchuck. Old mining camps are attracting increasing numbers of visitors.

Through the development of suitable areas on existing publicly-administered lands, approximately one-third of the projected picnicking and camping needs for the year 2020 can be met. Additional private lands would be required by that year to supplement the existing public lands, which must remain in public ownership to insure availability.

The broad recreation goal is to promote well-planned development and protection of the existing resources and to provide an opportunity for the satisfaction of present and future outdoor recreation demands of the population. Based on Federal ownership of land, plans and programs of recreation suppliers, and expected population concentrations as well as outdoor recreation needs, the assumption is made that the Federal agencies would provide 20 percent of the future required water-related opportunities, while the State, county and local agencies, and the private sector, would supply 35, 30, and 15 percent, respectively.

The recreation development contained in the Comprehensive Plan and as discussed below is intended to be compatible with the Washington Statewide Outdoor Recreation and Open Space Plan.

Additional facilities and acquisition and development of land and water areas are required in order to satisfy the above demand for water-related outdoor recreation. These specific land and water area needs are:

Recreation Land and Water Requirements
1960-2020

Activity	Unit	1960 Land	1960 Water	1980 Land	1980 Water	2000 Land	2000 Water	2020 Land	2020 Water
Swimming									
Beach area	Acres	0	0	0	0	0	0	1	0
Pools	Sq. Ft.	3,000	2,000	7,000	4,000	15,000	7,000	28,000	14,000
Boating, sailing, and water skiing	Acres	0	0	0	0	9	1,841	29	8,841
Camping	Acres	260	--	670	--	1,370	--	2,670	--
Picnicking	Acres	103	--	193	--	293	--	593	--
Hiking	Miles	0	--	0	--	0	--	47	--

Source: Appendix X, Recreation.

The recreation development contained in the Comprehensive Plan for the Stillaguamish Basin, is discussed by period as follows:

1970-1980—Improvement and further development of recreation facilities at the 35 publicly-administered outdoor recreation areas within the Basin, along with development of new areas on existing publicly-administered land is recommended during this period. Access and improvement to State shorelines along the South Fork of the Stillaguamish River, Lake Cavanaugh, and numerous points on Puget Sound is called for, together with the designation of a network of scenic roads to provide travel links between recreation attractions, which would enhance driving for pleasure and sightseeing opportunities within the Basin. Where practical, hiking and riding trails should also be developed within the corridor of scenic roads.

Approximately 40 recreation areas are proposed for expansion or development before 1980. Acquisition of scenic access easements is proposed along the rivers and streams to insure that greenbelts are provided within areas which are presently urbanized, and those destined for residential development. Preservation as open space of the natural flood plain along the Stillaguamish is recommended, consistent with a portion of the Comprehensive Plan discussed under Flood Control.

A State system is suggested to retain the important recreation rivers or river segments for public use in their natural state. The North and South Forks of the Stillaguamish River are recommended for study. Investments for recreation facilities are tabulated below for the various water-related improvements.

Outdoor Recreation Improvements
1970-1980

Feature	Investment Costs ($1000)	Average Annual Costs: Interest & Amortization ($1000)	Average Annual Costs: Operation & Maintenance ($1000)	Average Annual: Total ($1000)	Average Annual: Benefits ($1000)
Campgrounds	9,380				
Picnic areas	791				
Beaches	--				
Swimming pools	100				
Boating facilities	185				
Planning and design	2,614				
Land acquisition	7,350				
Total	$20,420	$955	$301	$1,256	$1,484

Fish and Wildlife
Project and Program Costs
1970-1980

Feature	Investment Costs ($1000)	Average Annual Costs: Interest & Amortization ($1000)	Average Annual Costs: Operation & Maintenance ($1000)	Average Annual Costs: Total ($1000)	Average Annual: Benefits ($1000)
Projects	5,220	272	249	521	1,528
Programs	160[1]				2
Total	$5,380	$272	$249	$521	$1,528

[1] Cumulative program costs for the period.

[2] Program benefits included in with project benefits.

1980-2000—During this period, more extensive development of public lands is anticipated, although acquisition of private lands would be required to fulfill the demand. Need for all types of recreational development would continue during this period. Total recreation development costs during this period are estimated at $13,500,000 and costs for land acquisition estimated at $7,300,000, including buffer zones, with over 40 sites planned for expansion or new development.

2000-2020—After the year 2000 additional development of public lands is planned with some further acquisition of private lands expected. All types of recreational development would continue during this period. Total recreation development costs during this period are estimated at $25,900,000 and land acquisition costs estimated at $14,300,000, including buffer zones, with over 50 sites proposed for expansion or new development.

Fish and Wildlife

The Stillaguamish Basin offers numerous opportunities for projects and programs that, if implemented, would maintain and possibly enhance wildlife populations, and increase fish and shellfish production. That portion of the Comprehensive Plan dealing with fish and wildlife are discussed by periods as follows:

1970-1980—Measures to fulfill fish needs planned for early action include the construction of a fish hatchery, a steelhead rearing pond, acquisition and development of access to 50 miles of stream, and acquisition and development of 4 access areas on salt water. Passage facilities on the South Fork is also programmed.

Projects to propagate game populations include acquisition and development of 600 acres at Hat Slough for waterfowl habitat, and add to the existing game farm capacity to produce an additional 2,500 pheasants.

Programs would be implemented which would benefit both hunters and fishermen. These programs include the development of new fish toxicants, fish disease control and lake fertilization techniques. Those programs associated with game animals include cooperative programs with private land owners to preserve habitat and insure hunter success, development of educational programs to stress renewable aspects and proper harvest of wildlife, and new methods for wildlife population analysis, habitat improvement techniques, and compatible forest-wildlife practices. Project and program costs included in the Comprehensive Plan for fish and wildlife are tabulated as follows:

Projects

a. Acquisition and development of access to four lakes.
b. Acquisition of 50 miles of streambank access.

c. Acquisition and development of four saltwater access areas.
d. Enlargement of two lakes.
e. Construction of a trout hatchery to stock lakes.
f. Construction of addition to existing steelhead and searun cutthroat trout rearing complex.
g. Construction of a game fish hatchery.
h. Acquisition and development of waterfowl habitat on Hat Slough.
i. Enlargement of existing pheasant game farm.
j. Construction of modifications to existing fish passage facility at Granite Falls.
k. Correction of clay slides in North and South Forks of Stillaguamish River.

Programs

a. Develop fish disease controls and new toxicants.
b. Develop lake fertilization techniques.
c. Perform cross-sectional surveys of streams.
d. Make wildlife population analysis and timberland management practices studies, develop habitat improvement techniques and an education program on proper game hunting concepts, and begin a program with land owners for game habitat retention and hunter access.
e. Locate, survey and mark boundaries of all State second class tidelands.

1980-2000—During this time period, projects would improve the habitat of migratory salmon. These projects include fish passage over major barriers which would provide an additional 17 miles of stream habitat. Habitat improvement projects would be made on 34 streams, providing an additional 21 miles of fish habitat. One salmon hatchery and a spawning channel 1 mile in length would be constructed to accommodate the required number of fish to meet projected needs. Ten acres of rearing ponds also would be provided. Programs initiated in the present to 1980 time period would be continued in this period.

2000-2020—In this period three hatcheries, a spawning channel 1 mile in length, and 15 acres of rearing facilities would be constructed for migratory salmon. Programs initiated earlier to improve fish and game would be continued.

Fish and Wildlife
Projects and Programs
1980-2000

Project	Investment Costs
Construct fish passage facilities on Pilchuck and Canyon Creeks	39,000
Improve habitat on four streams (21 mi.)	54,000
Construct 10 acres rearing ponds	55,000
Construct one salmon hatchery	1,020,000
Construct 1 mile of salmon spawning channel	700,000
Game fish and wildlife improvements	3,700,000
Total	$5,568,000
Program	
Continuation of fish and wildlife programs	$320,000

Fish and Wildlife
Projects and Programs
2000-2020

Project	Investment Costs
Construct three salmon hatcheries	3,060,000
Develop 15 acres of salmon rearing facilities	83,000
Develop 1 mile of salmon spawning channel	700,000
Game fish and wildlife improvements	5,569,000
Total	$9,412,000
Program	
Continuation of fish and wildlife programs	$320,000

COST-BENEFIT SUMMARY

The investment costs by resource function are shown in Tables 5-19 and 5-20 for the Stillaguamish Basin with the costs distributed between Federal, State, local, and private interests. Average annual costs and benefits also are shown for projects recommended for implementation prior to 1980. The investment costs include cumulative annual program costs for each of the three planning periods as shown in Table 5-19 and capital project costs as shown in Table 5-20. Interest and amortization costs are based on a 100-year economic life with appropriate allowances made for major replacements. An interest rate of 4-5/8 percent was used in the economic analysis. All measures proposed for early action are justified on the basis of tangible benefits. Benefits for municipal and industrial water supply and water quality improvement were assumed equal to annual charges.

Investment costs were allocated to the various interests on the basis of available information including the technical appendices, multiple-purpose project studies, and experience at similar projects.

TABLE 5-19. Program investment costs,[1] Stillaguamish Basin ($1000)

Feature	Private	Government			Total
		Local	State	Federal	
			1970-1980		
Water Quality Control	28	28	73	31	160
Flood Control	0	19	4	2	25
Watershed Management	14,709	3,301	3,248	7,435	28,693
Fish and Wildlife	0	0	160	0	160
Subtotal	$14,737	$3,348	$ 3,485	$ 7,468	$29,038
			1980-2000		
Water Quality Control	42	42	150	66	300
Flood Control	0	32	9	5	46
Watershed Management	14,339	919	4,331	9,891	29,480
Fish and Wildlife	0	0	320	0	320
Subtotal	$14,381	$ 993	$ 4,810	$ 9,962	$30,146
			2000-2020		
Water Quality Control	54	54	162	70	340
Flood Control	0	32	9	5	46
Watershed Management	14,160	1,948	4,331	8,108	28,547
Fish and Wildlife	0	0	320	0	320
Subtotal	$14,214	$2,034	$ 4,822	$ 8,183	$29,253
Total	$43,332	$6,375	$13,117	$25,613	$88,437

[1] Cumulative annual program costs over the period.

TABLE 5-20. Project investment costs[1] and cost-benefit summary, Stillagaumish Basin ($1000)

Feature	Investment Costs					Annual Costs			Annual Benefits	
		Government								
	Private	Local	State	Federal	Total	Interest & Amortization[2]	Operation & Maintenance	Total	Total	Net
			1970-1980							
M&I Water Supply	0	564	0	0	564	44	31	75	75	0
Irrigation	540	0	0	0	540	42	48	90	90	0
Water Quality Control	670	370	185	635	1,860	105	22	127	127	0
Flood Control	0	800	0	6,900	7,700	400	54	454	500	46
Watershed Management[3]	0	496	0	1,149	1,645	77	15	92	288	196
Recreation	3,063	6,126	7,147	4,084	20,420	955	301	1,256	1,484	228
Fish and Wildlife	0	0	5,220	0	5,220	272	249	521	1,528	1,007
Subtotal	$ 4,273	$ 8,356	$12,552	$12,768	$ 37,949	$1,895	$720	$2,615	$4,092	$1,477
			1980-2000							
M&I Water Supply	0	858	0	0	858					
Irrigation	540	0	0	0	540					
Water Quality Control	830	772	386	1,306	3,294					
Flood Control	0	400	0	3,300	3,700					
Watershed Management[3]	0	1,694	0	3,926	5,620					
Recreation	3,120	6,240	7,280	4,160	20,800					
Fish and Wildlife	0	0	5,568	0	5,568					
Subtotal	$ 4,490	$ 9,964	$13,234	$12,692	$ 40,380					
			2000-2020							
M&I Water Supply	0	1,152	0	0	1,152					
Irrigation	0	0	0	0	0					
Water Quality Control	1,380	840	420	1,340	3,980					
Flood Control	0	0	0	0	0					
Watershed Management[3]	0	395	0	915	1,310					
Recreation	6,030	12,060	14,070	8,040	40,200					
Fish and Wildlife	0	0	9,412	0	9,412					
Subtotal	$ 7,410	$14,447	$23,902	$10,295	$ 56,054					
Total	$16,173	$32,767	$49,688	$35,755	$134,383					

1 Capital project costs.

2 Of initial investment and major replacement.

3 Investment for structural measures installation only.

SEQUENCE OF DEVELOPMENT

The projects and programs are summarized in Table 5-21 by time periods. The project numbers identify features on the Basin map (Figure 5-3).

TABLE 5-21. Future projects and programs, Stillaguamish Basin

PROJECTS PRIOR TO 1980

Municipal and Industrial Water Supply

1. Increase of transmission capacity of Arlington, Stanwood, Granite Falls and rural communities.

Irrigation

2.* Installation of individual farm irrigation pumping and sprinkler systems (private).

Water Quality Control

3. Expansion of treatment, disinfection and sewage interception facilities–Stanwood, Arlington and Granite Falls.

Flood Control

4. Construction of levees–Stanwood.

Watershed Management

5. Small watershed multiple-purpose project–Lower Stillaguamish.
6. Small watershed multiple-purpose project–Church Creek.

Recreation

7. Development of one recreation site at mouth of Stillaguamish River.
8. Development of one recreation site in this vicinity.
9. Development of three recreation sites along Stillaguamish River from mouth to Arlington.
10. Development of two recreation sites along Pilchuck Creek from mouth to Cavanaugh Lake.
11. Development of four recreation sites along North Fork of Stillaguamish River from Arlington to National Forest.
12. Development of four recreation sites along the South Fork of the Stillaguamish River from Arlington to the National Forest.
13. Development of 20 recreation sites in the National Forest.

Fish and Wildlife

14.* Acquisition and development of access to four lakes.
15.* Acquisition of 50 miles of streambank access.
16.* Acquisition and development of four salt water access areas.
17. Enlargement of Ebeny and Twin Lakes.
18.* Construction of a trout hatchery to stock lakes.
19.* Construction of addition to existing steelhead and searun cutthroat trout rearing complex.
20.* Construction of a game fish hatchery.
21. Acquisition and development of waterfowl habitat on Hat Slough.
22.* Enlargement of existing pheasant game farm.
23. Construction of modifications to existing fish passage facility at Granite Falls.
24. Correction of clay slides in North and South Forks of Stillaguamish River.

PROGRAMS PRIOR TO 1980

Water Quality Control

a. Establish and operate water quality surveillance stations at key salt and fresh water locations and prepare comprehensive sewerage plan for the Basin.

Flood Control

b. Establish and administer county-wide flood plain zoning measures under flood plain management program (county-city responsibility under State law using Federal flood plain information).

Watershed Management

c. Provide technical assistance and management for State and Federal lands.
d. Provide technical assistance for on-farm and other private practices.

Fish and Wildlife

e. Develop fish disease controls and new toxicants.
f. Develop lake fertilization techniques.
g. Perform cross-section surveys of streams.

*Not shown on Figure 5-3.

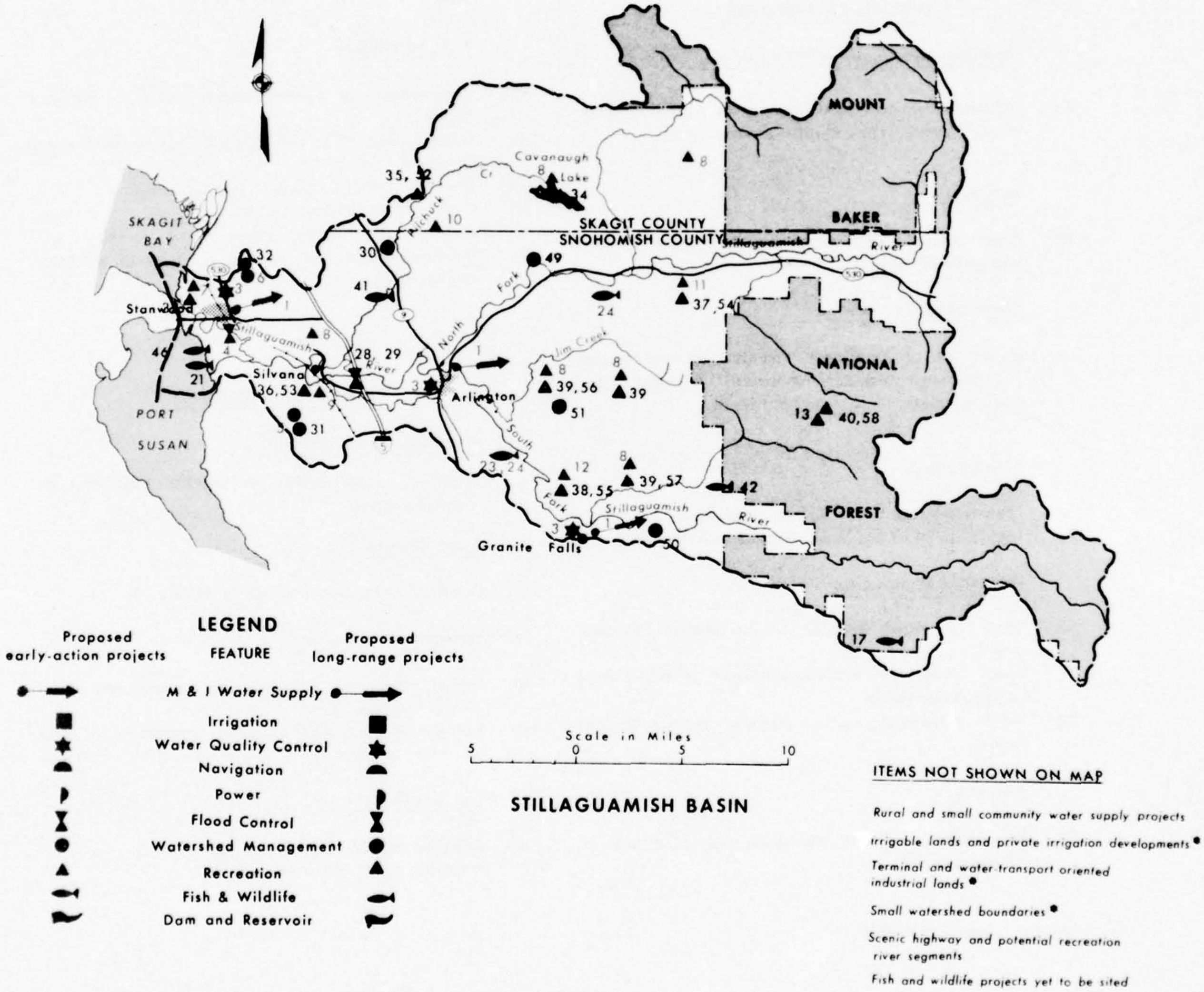


FIGURE 5-3. Comprehensive Plan elements

TABLE 5-21. Future projects and programs, Stillaguamish Basin (Cont'd)

h. Make wildlife population analysis and timberland management practices studies, develop habitat improvement techniques and an education program on proper game hunting concepts and begin a program with land owners for game habitat retention and hunter access.

i. Locate, survey, and mark boundaries of all State-owned second class tidelands in the Basin. Take steps to reserve all such lands for public use except as required for specific circumstances.

j. Perform an inventory of shellfish stocks and recreational use of tidelands.

PROJECTS 1980-2000

Municipal and Industrial Water Supply

25. Increase of transmission capacity of Arlington, Stanwood, Granite Falls and rural communities.

Irrigation

26.* Construction of individual farm irrigation pumping and sprinkler systems (private).

Water Quality Control

27.* Expansion of treatment, disinfection and sewage interception facilities—Stanwood, Arlington and Granite Falls.

Flood Control

28. Improvement of levee—Silvana to Arlington.
29. Improvement of floodway—Silvana to Arlington.

Watershed Management

30. Small watershed multiple-purpose project—Pilchuck Creek.
31. Small watershed multiple-purpose project—Lower Stillaguamish River.
32. Small watershed multiple-purpose project—Church Creek.

Recreation

33. Development of one recreation site at mouth of Stillaguamish River.
34. Development of one recreation site at Cavanaugh Lake.
35. Development of two recreation sites along Pilchuck Creek from mouth to Cavanaugh Lake.
36. Development of three recreation sites along the Stillaguamish River from mouth to Arlington.
37. Development of five recreation sites along the North Fork of the Stillaguamish River from Arlington to National Forest.
38. Development of four recreation sites along the South Fork of the Stillaguamish River from Arlington to National Forest.
39. Development of one recreation site in this vicinity.
40. Development of 25 recreation sites in the National Forest.

Fish and Wildlife

41. Construction of a fish passage facility on Pilchuck Creek.
42. Construction of a fish passage facility on Canyon Creek.

43.* Construction of 10 acres of rearing ponds.

44.* Construction of a salmon hatchery.

45.* Construction of one salmon spawning channel.

46.* Develop access and parking facilities to all State-owned beaches.

PROGRAMS 1980-2000

Water Quality Control

k. Continue water quality monitoring, evaluation and control program.

Flood Control

l. Continue flood plain management program.

Watershed Management

m. Provide technical assistance to on-farm and other private practices.

n. Provide technical assistance and management for State and Federal lands.

Fish and Wildlife

o. Continue fish and wildlife programs.

p. Improve beaches for clam culture.

*Not shown on Figure 5-3.

TABLE 5-21. Future projects and programs, Stillaguamish Basin (Cont'd)

PROJECTS 2000-2020

Municipal and Industrial Water Supply

47. Expansion of water supply transmission lines at Arlington, Stanwood, Granite Falls and rural communities.

Water Quality Control

48.* Expansion of treatment, disinfection and sewage interception facilities–Stanwood, Arlington and Granite Falls.

Watershed Management

49. Small watershed multiple-purpose project–North Fork Stillaguamish River.
50. Small watershed multiple-purpose project–South Fork Stillaguamish River.
51. Small watershed multiple-purpose project–Jim Creek.

Recreation

52. Development of two recreation sites along Pilchuck Creek from mouth to Cavanaugh Lake.
53. Development of three recreation sites along Stillaguamish River from mouth to Arlington.
54. Development of seven recreation sites along North Fork of Stillaguamish River from Arlington to National Forest.

*Not shown on Figure 5-3.

55. Development of five recreation sites along South Fork of Stillaguamish River from Arlington to National Forest.
56. Development of two recreation sites in this vicinity.
57. Development of one recreation site in this vicinity.
58. Development of 35 recreation sites in National Forest.

Fish and Wildlife

59.* Construction of three salmon hatcheries.
60.* Construction of 15 acres of salmon rearing facilities.
61.* Construction of 1 mile of salmon spawning channel.

PROGRAMS 2000-2020

Water Quality Control

q. Continue water quality monitoring, evaluation and control program.

Flood Control

r. Continue flood plain management program.

Watershed Management

s. Provide technical assistance to on-farm and other private practices.
t. Provide technical assistance and management for State and Federal lands.

Fish and Wildlife

u. Continue fish and wildlife programs.

PLAN ACCOMPLISHMENTS

The Comprehensive Plan accomplishments are summarized by time periods in Table 5-22. As shown, Basin needs are largely met by the Plan except for pleasure boating. None of the Basin's moorage needs would be provided in the Basin under the Plan, but are planned for in the Skagit-Samish Basins.

Critical low flow conditions are foreseen in the Stillaguamish River channel near Stanwood under natural conditions. However, the proposed plan would provide for augmenting the flow which now leaves the Stillaguamish channel via Hat Slough. With this diversion and proposed waste treatment measures minimum water quality standards could be maintained in the Stillaguamish River at Stanwood.

Flood control needs would be substantially met by 2000 except for a relatively small agricultural area upstream from Arlington. This 900-acre area could not be economically protected from flooding unless multiple-purpose floodwater storage were to become economical in the Basin. In the meantime flood plain zoning would materially aid in limiting future flood damages.

All watershed management needs would be met except urban water management. These needs would be entirely met by the year 2020. In the preceding time period a residual is shown as intensive land use would be required to achieve a minimum density in order to facilitate project undertaking.

The sport and commercial fishery needs are assumed to be met by the projects contained in the

TABLE 5-22. Comprehensive Plan accomplishments, Stillaguamish Basin

Feature	Units	To 1980 Needs	To 1980 Accomp.	To 1980 Residual	To 2000 Needs	To 2000 Accomp.	To 2000 Residual	To 2020 Needs	To 2020 Accomp.	To 2020 Residual
M&I Water Supply	mgd	2.3	2.3	0	6.7	6.7	0	14.4[4]	14.4[4]	0
Irrigation	1000 Acre-Feet	7.7	7.7	0	15.4	15.4	0	15.4	15.4	0
Water Quality Control										
Waste	1000 Population Equivalents	414	414	0	941	941	0	1,821	1,821	0
Flow[1]	cfs	20	20	0	30	30	0	40	40	0
Navigation										
Commercial	1000 Short Tons	0	0	0	0	0	0	0	0	0
Pleasure Boats	Wet Moorages	400	0	400[3]	770	0	770[3]	1,500	0	1,500[3]
Power[2]										
Flood Control	$1000 Damage Reduction	380	193	187	690	496	194	1,310	1,116	194
Watershed Management										
Flood Prevention	1000 Acres	24.5	24.5	0	24.5	24.5	0	24.5	24.5	0
Watershed Protection and Rehabilitation[5]	1000 Acres	433.6	433.6	0	433.6	433.6	0	433.6	433.6	0
Water Management[6]										
Agricultural	1000 Acres	13.5	13.5	0	22.6	22.6	0	30.1	30.1	0
Urban	1000 Acres	12.6	5.6	7.0	12.6	9.1	3.5	13.0	13.0	0
Recreation	1000 User-Days	1,240	1,240	0	2,640	2,640	0	5,140	5,140	0
Fish and Wildlife										
Sport										
Fishing	1000 User-Days	230	230	0	562	562	0	1,107	1,107	0
Hunting	1000 User-Days	51	51	0	116	116	0	155	155	0
Commercial Fishing	1000 Pounds	3,133	3,133	0	5,290	5,290	0	7,366	7,366	0

1 Stillaguamish River.

2 Power needs were projected for the Puget Sound Area only.

3 Needed moorages would be provided for in the Skagit-Samish Basins.

4 In addition an estimated 3.8 mgd would be supplied from the Stillaguamish River to meet the Camano Island demand.

5 The necessary level of management is assumed to be established throughout the Basin, otherwise some residual could occur.

6 Needs and accomplishments are cumulative.

Plan as the future consumptive withdrawals for municipal and industrial water supply and irrigation would not reduce the minimum flows appreciably during the critical summer season in the various rivers over that that has historically occurred. Upon completion of detailed river studies to determine the required minimum and optimum flows for fish production, as called for during the early action period, adjustments may be made to the Plan.

The sport and commercial fishery needs would be satisfied by the Plan assuming that present pollution problems are corrected. As only specific solutions for the early action period were provided for wildlife needs, subsequent periods were assumed to be satisfied by projects and programs that would be developed later. A reduction in hunter success is anticipated with a willingness of hunters to accept a lower success ratio necessary in order to meet projected needs. Hunters also may be required to utilize hunting areas in Eastern Washington.

ALTERNATIVE ELEMENTS

Alternative measures to those elements contained in the Comprehensive Plan and reasons for not adopting these alternatives are discussed in this section.

Alternatives to Municipal and Industrial Water Supply Elements

Desalinization is too expensive to make the use of salt water competitive with fresh water sources. Either surface or ground water supplies are adequate for projected municipal and industrial use, including a small out-of-Basin transfer to Camano Island past 2000.

Alternatives to Irrigation Elements

Ground water recharge, estimated to be 40,000 acre-feet annually, is sufficient to meet total annual Basin irrigation demands of 20,200 acre-feet in 2020. However, it is estimated that only half of the recharge could be recaptured by wells. Thus, the adequacy of ground water as the sole source for irrigation as well as municipal and industrial water, especially during peak flows, is doubtful. Stillaguamish River flows would be adequate to supply municipal and industrial and irrigation peak uses; however, by 2020 total peak use would approach the maximum which could be withdrawn from the stream without encroaching on the net flow required to maintain water quality. Irrigation needs could be met by diversions from the Sauk River at Darrington, but at greater expense than using ground water.

Alternatives to Water Quality Control Elements

Water quality would be maintained in the Basin by treating wastes to the point where minimum low streamflows would absorb residual wastes without lowering quality below State standards. Various methods of treatment are available to meet each waste control problem. At Stanwood secondary treatment of municipal and industrial wastes, with land disposal of sludge from the treatment plant would be a means of waste disposal. An alternative, found to be uneconomical, would be disposal of sewage or primary treatment effluent in deep salt water outside of Port Susan.

With the proposed waste treatment at Stanwood and low flow diversions from the flood control works at the head of Hat Slough, suitable water quality would be maintained in the lower Stillaguamish River near Stanwood. An alternative to diversion would be augmentation of total exchanges by salt water pumping from Port Susan during the dry season. However, the alternative would not be competitive, economically, with the proposed flood control diversion. At Arlington, secondary treatment would also be required. As recreational use of the Basin increases, suitable waste collection and treatment would be necessary. Resorts in the upper Basin and cabins along the streams are in this recreational category.

Alternatives to Flood Control Elements

Single or multiple-purpose flood storage was investigated for use in lieu of the proposed channel and levee improvements. Flood control, as well as other benefits, would be more widespread with storage. However, the high cost of storage, including fairly extensive relocation costs on the North Fork, was found to be uneconomical at this time. As power costs increase in the Pacific Northwest with the growth of nuclear electric power plants, multiple-purpose storage including power may eventually become feasible. Until flood storage in a multiple-purpose reservoir is possible, flood control would not be feasible upstream from Arlington. Flood plain

zoning and management would be a necessary part of the overall flood control plan, but would not be complete substitutes for the proposed flood control measures. Floodproofing of existing structures might find economic application in isolated instances, but would not be a feasible substitute for the proposed measures. Relocation of flood-damageable structures to high ground was also found to be uneconomical.

Storage projects could conflict with ecological and environmental objectives which are to retain rivers where possible in a natural free-flowing state. This factor was the overriding reason for excluding, at this time, storage development in the Stillaguamish Basin from the long-range portion of the Plan.

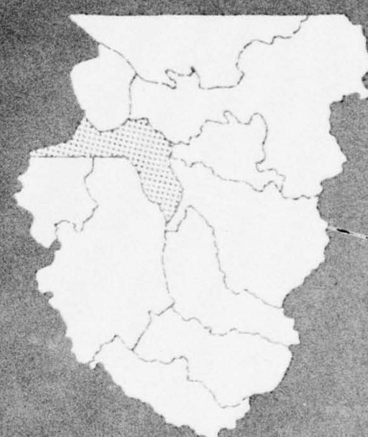
Alternatives to Recreation Elements

As limited information was provided with regard to specific locations of recreation development, no analysis could be made to determine if sites and proposed developments were necessarily the most economical that could be provided to achieve a given amount of recreation benefits. Accordingly, the single-purpose plan was adopted in toto.

Alternatives to Fish and Wildlife Elements

Proposed fish and wildlife measures would provide for increasing recreational fishing and hunting and commercial fishing. Most of the recreational and all of the commercial catches of Stillaguamish Basin salmon are outside the Basin. An alternative to Basin fish and game increase measures would be to provide compensating measures in other basins. However, the most desirable and effective program for increasing Puget Sound Area fish and wildlife would be to improve each basin to maintain nearly a constant level of fish and game production over the entire area, depending on water and land areas available. All potential means for increasing fish and game production in the Stillaguamish Basin have been considered. Measures to increase natural fish habitat productiveness have been weighed against hatchery production, and both are included in the Plan to provide the most economical overall solution to meeting recreational and commercial needs. The fish and wildlife improvements which can most quickly and efficiently increase productivity are placed in the earlier schedules.

Whidbey-Camano Islands



WHIDBEY—CAMANO ISLANDS

DESCRIPTION OF ISLANDS

GENERAL

The Whidbey-Camano Islands comprise 209 square miles of land and slightly over 1 square mile of fresh water. The Islands have 221 miles of salt water shoreline. Whidbey Island is separated from the mainland by deep salt water. A high-level arch bridge over Deception Pass provides vehicular access to the Island. Camano Island lies between Whidbey Island and the mainland, and is separated from the mainland by a narrow slough which is bridged near Stanwood.

The Islands have one of the most uniform marine climates of any area in the United States. The Cascade Range to the east shelters the Islands from cold continental winds, and temperatures are modified by prevailing westerly winds rarely going over 90°F or below 0°F. The average annual precipitation and temperature at Coupeville on Whidbey Island are about 18 inches and 50°F, respectively.

There are no major streams on either Whidbey or Camano Islands. A few small streams in the southern part of Whidbey Island are fed by springs that flow throughout the year. There are 40 fresh water lakes on the Islands, mostly smaller than 15 acres. Ground water is the only significant source of water supply on both Islands. The Islands contain many separate aquifers which generally furnish an adequate water supply for domestic use or small scale irrigation. Wells yield 20 gallons per minute from aquifers above sea level, while those 75 feet below sea level yield 80 gallons per minute. The maximum yield has been 600 gallons per minute. The physiographic characteristics of the Whidbey-Camano Islands are described in Appendix V, Water-Related Land Resources.

PRESENT SITUATION

Local Economy

There were 19,900 people in the Islands in 1963 with Oak Harbor, Coupeville and Langley being the major population centers. An estimated one-third of the Islands' population lives in incorporated communities. Population changes in the Islands and their principal population centers are shown in Table 6-1.

TABLE 6-1. Historical population, Whidbey-Camano Islands

	1950	1960	1963	1967
Whidbey-Camano Islands	11,100	19,600	19,900	22,400
Principal cities and towns:				
Oak Harbor	1,193	4,590		5,100
Coupeville				675
Langley				472

Source: Appendix IV, Economic Environment, Appendix V, Water-Related Land Resources.

The rapid population increase of Oak Harbor is attributed to the establishment of military bases. Coupeville, the County seat, was incorporated in 1910, and Langley was incorporated in 1913. Agriculture, recreation, and military installations form the base of the local economy. No industrial enterprises of any size are on the Islands and most of the agricultural products are used locally. Agriculture is located largely on the northern half of both Islands. Other employment opportunities are in industries of the Everett-Seattle-Tacoma industrial areas.

Land Use

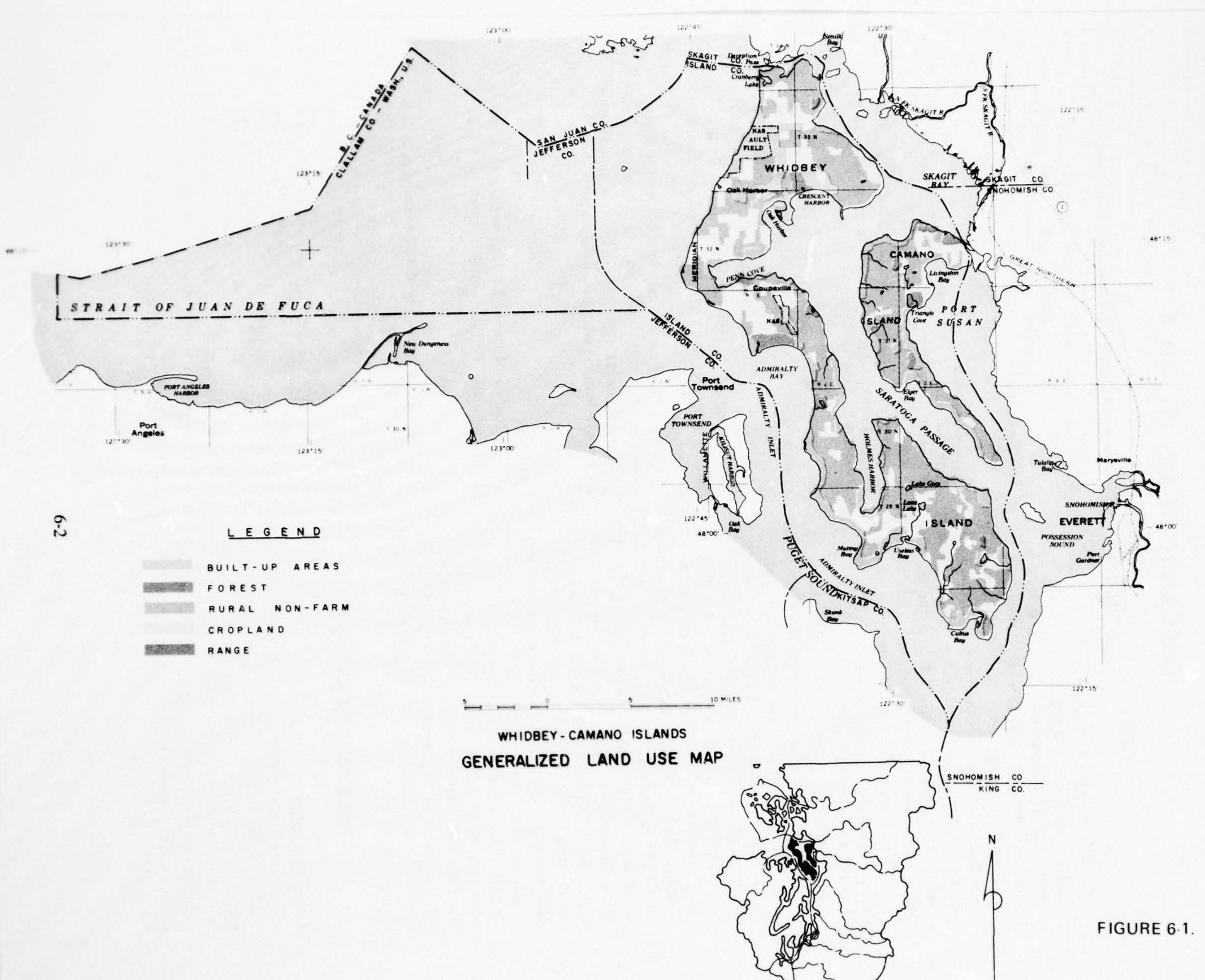
Within the Islands the land area is 133,000 acres as tabulated in Table 6-2 and shown on Figure 6-1.

TABLE 6-2. Present land use, Whidbey-Camano Islands

Land Use	Acres	Percent
Cropland	23,000	17.2
Rangeland	2,500	2.0
Forest[1]	84,100	63.1
Rural nonfarm	12,400	9.4
Intensive	11,000	8.3
Total	133,000	100.0

[1] Includes open areas normally associated with forest.

Source: Appendix V, Water-Related Land Resources.


STRAIT OF JUAN DE FUCA
B.C. – CANADA
CLALLAM CO. – WASH., U.S.
SAN JUAN CO.
JEFFERSON CO.
ISLAND CO.
SKAGIT CO.
SNOHOMISH CO.
KING CO.
KITSAP CO.
WHIDBEY
ISLAND
CAMANO
ISLAND
PORT SUSAN
SARATOGA PASSAGE
HOLMES HARBOR
ADMIRALTY INLET
ADMIRALTY BAY
PUGET SOUND
SKAGIT BAY
POSSESSION SOUND
EVERETT
SNOHOMISH
Marysville
Port Townsend
PORT TOWNSEND
Port Angeles
PORT ANGELES HARBOR
New Dungeness Bay
Oak Harbor
CRESCENT HARBOR
PENN COVE
Coupeville
NAS AULT FIELD
MERIDIAN
GREAT NORTHERN
KILISUT HARBOR
Oak Bay
Livingston Bay
Triangle Cove
Tulalip Bay
Port Gardner
Cultus Bay
Mutiny Bay
Useless Bay
Lake Goss
Skunk Bay
Similk Bay
Deception Pass
Cranberry Lake
Elger Bay
L E G E N D
BUILT-UP AREAS
FOREST
RURAL NON-FARM
CROPLAND
RANGE
10 MILES
WHIDBEY-CAMANO ISLANDS
GENERALIZED LAND USE MAP
N
FIGURE 6-1.

While forest use is indicated on 63 percent of the land, the area is not classified as commercial forest land due to the complex pattern of small ownerships. Generally, the second growth is of commercial importance for only selected local markets. Croplands (including row crops, hay, pasture and forage) use 17 percent of the lands located on the deeper parts of the glacial soils. Growing of small grain, vegetables, nursery crops and row crops, along with cropland not used, accounts for 19 percent of the cropland. The remaining cropland is used to produce hay, pasture and silage to support dairy and livestock industries.

Intensive land use accounts for about 8 percent of the Island's land area. Present intensive land use requirements on Whidbey Island are being met at several concentrated points–mainly Oak Harbor and Coupeville. Scattered intensive uses of a residential nature occur throughout the Islands, particularly on or near waterfront lands. An important limitation on the population growth of Whidbey Island has been the access by ferry with the Everett-Seattle area. Intensive land use is tabulated by acres in Appendix V, Water-Related Land Resources, as follows: railroads 0, roadways 3,000, airports 5,000, and urban (built-up) 3,000, for a total of 11,000 acres.

Rural nonfarms use 12,400 acres or 9 percent of the land of the Island. The nonfarm developments generally are near the shorelines, used for recreation and retirement residences, and are bedroom communities for the Everett-Seattle-Tacoma metropolitan area.

Land ownership is shown in Table 6-3.

TABLE 6-3. Land ownership, Whidbey-Camano Islands

Ownership	Percent
Private	87.5
Private corporate	1.5
Federal	6.1
State	4.3
Local	0.6
Total	100.0

Source: Appendix V, Water-Related Land Resources.

PROJECTED ECONOMY AND LAND USE

Local Economy

The Islands' base economy is expected to continue the present trend of development, which is urban and recreational. The projected growth trend of the Puget Sound Area and the Northern Division[1] is shown in Table 6-4.

[1] Economic Study of Puget Sound and Adjacent Waters.

TABLE 6-4. Economic projections, Whidbey-Camano Islands

					Average Annual Growth Trends (Percent)			
	1963	1980	2000	2020	1963 to 1980	1980 to 2000	2000 to 2020	1963 to 2020
North Division								
Population (1000's)	151.0	185.5	249.9	341.5	1.2	1.5	1.6	1.4
Employment (1000's)	45.5	57.9	78.2	106.7	1.4	1.5	1.5	1.5
Gross Regional Product ($1,000,000)	369.0	848.0	1,800.0	3,977.0	5.0	3.9	4.0	4.3
Whidbey-Camano Islands								
Population (1000's)	19.9	56.0	80.9	115.0	6.3	2.1	1.6	3.1

Source: Appendix IV, Economic Environment, Appendix V, Water-Related Land Resources.

Farming is expected to continue on a limited scale but would be of decreasing importance to the Islands' economy. Recreation areas and facilities are expected to expand markedly along the waterfront areas.

The population projection in Table 6-4 is higher than the 49,500 projection for the year 2020, as is shown in the Economic Appendix. The population has been increased to more clearly reflect the effect of the recent Boeing Airplane Plant constructed in the Everett area, the projected expansion of the Everett Harbor area, and an anticipated bridge connection with the mainland. As a direct result of this projected expansion, Whidbey and Camano Islands are expected to become bedroom communities for these areas with a 2020 population of 115,000. Accordingly, the population of adjacent basins was adjusted to retain the total population growth of the Puget Sound Area as projected in the Economic Base Study.

Without either a bridge link or an adjacent large industrial development, a population of the magnitude projected would not develop on the Islands. If a fleet of super ferries such as those used on the Seattle-Bremerton route were placed in operation in lieu of a bridge, approximately 2,500 people per hour could be transported during the morning and evening peak periods. This would limit the population expansion of the Islands to about 80,000 year-round residents by the year 2020.

The Whidbey Island Naval Air Station expansion is expected to be the mainstay of the economy in the northern portion of Whidbey. The remainder of the Island, as mentioned above, would be developed in urban homesites for both seasonal and residential population influx. The addition of small boat moorages around the Island would boost the seasonal economy. Numerous small business establishments would be developed and seasonal dweller on both Whidbey and Camano Islands.

There is not expected to be any large employment industry established in the Islands. Further economic projections by industry can be obtained from Appendix IV, Economic Environment.

Future Land Use

The projected land use of the Whidbey-Camano Islands for 2020, shown on Figure 6-2, is compared in Table 6-5 with present land use. This land use pattern, based on the construction of a cross-Sound bridge and a bridge between the mainland and southern Whidbey Island, projects for the Whidbey-Camano Islands an intensive land use density increase from the present 1.8 persons per acre to 2.7 persons per acre by 2020.

TABLE 6-5. Present and projected[1] land use, Whidbey-Camano Islands (acres)[2]

Land Use	1967	1980	2000	2020
Forest	84,100	77,300	73,800	64,100
Rangeland	2,500	2,300	2,200	2,000
Cropland	23,000	22,000	22,500	21,000
Rural nonfarm	12,400	9,000	7,500	2,900
Intensive	11,000	22,400	27,000	43,000
Total	133,000	133,000	133,000	133,000
Population (1000's)	22,400	56,000	80,900	115,000
Density[3]	1.8	2.5	3.0	2.7

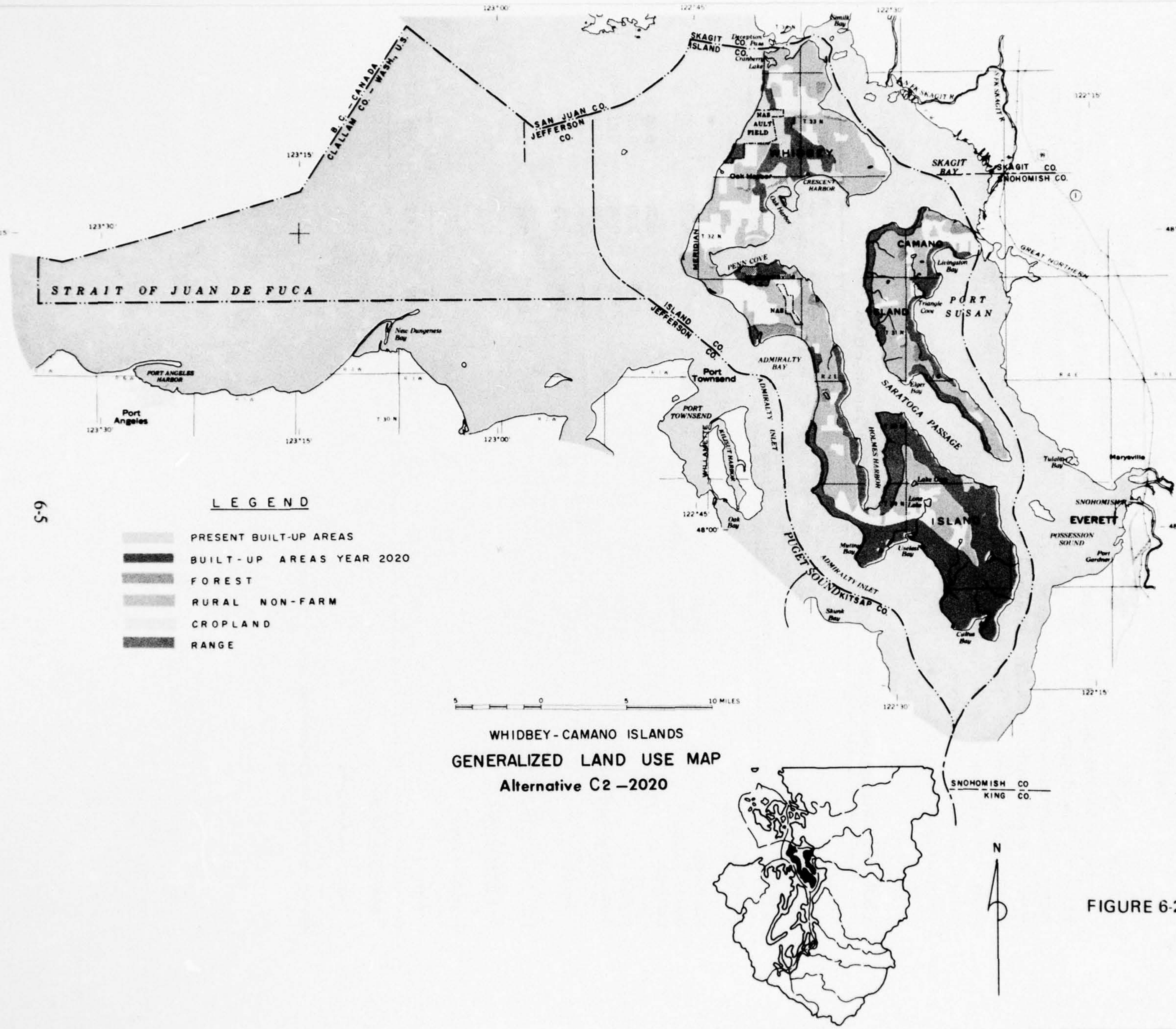
[1] Alternative Land Use Pattern C_2, see Puget Sound Area.

[2] Figures rounded to nearest hundred.

[3] Persons per intensive land use acre.

Source: Appendix V, Water-Related Land Resources.

Increasingly dense development is anticipated in the southern portion of the Island. Considerable development of the Islands for intensive uses—residential and recreation—would cause the displacement of some agricultural and forestry lands. As with the other basins in the Area, considerable conflict may arise over the use and development of waterfront lands, as the demand for this acreage increases and the available supply decreases.



WHIDBEY-CAMANO ISLANDS

GENERALIZED LAND USE MAP

Alternative C2 —2020

FIGURE 6-2.

WATER AND RELATED LAND RESOURCE NEEDS

MUNICIPAL AND INDUSTRIAL WATER SUPPLY

General

Nearly all municipal water supplies on the Islands use ground water as a source. Wells generally supply an adequate quantity during the year, although several wells are inadequate during the summer season. There are 150 individual systems serving approximately 72 percent of the resident and seasonal population. The 1965 municipal and industrial water use is shown in Table 6-6.

The Naval Air Station at Ault Field imports its water supply from the city of Anacortes which is located in the Skagit-Samish Basins.

Island County has limited water resources. There are no perennial streams or lakes capable of producing a significant water supply. Already populated areas within the Islands have experienced ground water shortages and the problem would become acute as the projected growth trend continues.

TABLE 6-6. Municipal and industrial water use in 1965, Whidbey-Camano Islands

		Surface Water (mgd)			Ground Water (mgd)		
System	Estimated Population Served	Average Daily Usage	Maximum Monthly Usage	Maximum Daily Usage	Average Daily Usage	Maximum Monthly Usage	Maximum Daily Usage
MUNICIPAL USE							
Oak Harbor	4,540	--	--	--	0.35	0.70	1.10
Naval Air Station[2]	4,800	1.00	1.40	2.00	--	--	--
Coupeville	1,200	--	--	--	0.12	0.24	0.30
Langley	455	--	--	--	0.15	0.30	0.43
Clinton	420	--	--	--	0.03	0.06	0.03
Rural community systems	4,770	--	--	--	0.45	0.89	1.38
Subtotal	16,185	1.00	1.40	2.00	1.10	2.19	3.29
RURAL-INDIVIDUAL USE	4,015	--	--	--	0.22[1]	0.44	0.66
INDUSTRIAL USE							
Naval Air Station[2]	--	1.50	1.75	2.00	--	--	--
Total	20,200	2.50	3.15	4.00	1.32	2.63	3.95

[1] Based upon 55 gpcd.

[2] Supplied by Anacortes.

Source: Appendix VI, Municipal and Industrial Water Supply.

TABLE 6-7. Projected municipal and industrial water needs,[1] Whidbey-Camano Islands

Year	Use	Total (Average Daily M.G.D.)	Total (1000's Acre-Feet Annually)	Net Needs[2] (M.G.D.)	Net Needs[2] (1000's Acre-Feet)
1965	Municipal	3.8	4.3		
	Industrial				
	Rural-Individual				
1980	Municipal	11.7	13.1	7.9	8.8
	Industrial			0	0
	Rural-Individual				
2000	Municipal	19.4	21.7	15.6	17.4
	Industrial	0	0	0	0
	Rural-Individual				
2020	Municipal	29.3	32.8	25.5	28.5
	Industrial	0	0	0	0
	Rural-Individual				

[1] Populations and subsequent water requirements were increased during formulation to more clearly reflect expected growth in the Islands. Reference "Projected Economy and Land Use," page 6-5.

[2] Cumulative total above 1965.

Source: Appendix VI, Municipal and Industrial Water Supply.

Present and Future Needs

Additional water supplies are needed on Whidbey Island now. Present ground water supplies on Camano Island are adequate until after 1980. Future municipal and industrial water needs are summarized in Table 6-7. Optimum or peak delivery capability of each of the municipal systems should be increased to meet the State's delivery standards for municipal distribution systems. The distribution systems should be capable of delivering the peak daily demands in addition to fire control requirements.

IRRIGATION

General

Irrigable lands on the Islands total 47,740 acres, of which 2,660 are presently irrigated and 45,080 are potentially irrigable. About 33,000 acres of potentially irrigable lands are on Whidbey and 12,000 on Camano. A large portion of these acreages are presently in woodlands. Soils of the potentially irrigable lands have developed from glacial drift which was deposited in moraines left by glaciers. Natural soil fertility is low.

If an adequate water supply could be obtained, approximately 30,000 acres could be irrigated on Whidbey Island by 1980. Studies contained in the Irrigation Appendix disclosed that importation of water to the Islands for irrigation is not economical. Consequently, no lands are projected for irrigation.

WATER QUALITY CONTROL

General

Surface water quality measurements have not been made for either Whidbey or Camano Islands.

Over 90 percent of the waste effluent, 10,500 PE, receivs primary treatment before being discharged to marine waters. Fisheries and recreation uses have set the minimum acceptable quality for the offshore marine waters. With present development and use, the marine water quality is excellent. The waste generation, treatment and discharges in 1965 are summarized in Table 6-8.

TABLE 6-8. Summary of municipal and industrial wastes, Whidbey-Camano Islands Islands, 1965

Receiving Water	Estimated Population Served	Nonseasonal Untreated Waste PE	Seasonal Untreated Waste PE	Treatment	Nonseasonal Waste Discharge PE	Seasonal Waste Discharge PE
Puget Sound						
Oak Harbor	3,500	3,500	--	Primary	2,550	--
Crescent Bay Seaplane Base	2,500	3,000	--	Primary	2,100	--
Crescent Bay Capehart Housing	800	1,000	--	Secondary	150	--
Coupeville	600	750	--	Primary	520	--
Langley	200	250	--	Primary	--	--
Ault Field	2,500	3,000	--	Primary	2,100	--
TOTAL	10,100	11,500	--	--	7,420	--
Municipal	--	11,500	--	--	7,420	--
Industrial	--	--	--	--	--	--

Source: Appendix XIII, Water Quality Control.

Present and Future Needs

To comply with the water quality standards, the sewage disposal facilities of many individuals and communities would have to be enlarged and expanded during the next few years. The population densities in many areas are reaching the point where community sewage disposal facilities are required. Agricultural activities are expected to decrease so that such practices as irrigation, pesticide application, and wastes from livestock would not have an impact on the water quality.

The water quality needs are primarily of waste collection, treatment, and surveillance. Adequate management of these expected wasteloads is the primary need of the future. The once negligible wastes associated with water craft are now becoming a significant factor in pollution of the marine waters adjacent to the Islands. Table 6-9 shows the projected waste production by municipal and recreational sources.

TABLE 6-9. Present and projected raw wasteloadings, Whidbey-Camano Islands (1000's PE)

Year	Municipal	Industrial	Recreational	Total	Net Needs[1]
1965	11.5	--	12	24	19
1980	70	--	19	89	85
2000	105	--	36	141	136
2020	144	--	42	186	181

[1] Cumulative raw wasteload requiring treatment above that receiving treatment in 1965.

Source: Appendix XIII, Water Quality Control.

NAVIGATION

General

There are no significant harbor developments on Camano Island but Whidbey Island has a number of minor harbors with ferry landings and/or piers for other local traffic. Existing navigation terminal facilities include two ferry landings, a few piers for fishing and small boats, a few log dumps, and facilities for use of the military installations. Water transport-oriented industry is limited to two saw mills. The small boat harbors and related facilities existing on salt water in 1966 contained a total of 102 wet moorages which could accommodate all year use.

Present and Future Needs

Although both Whidbey and Camano Islands are connected to the mainland by bridges, significant industrial development is not expected at either Island. Some increase in ferry terminals and small boat landings may be expected. However, there are several well protected harbor areas that could be developed as water terminals, if needed, to serve possible industrial plants. There are about 21 miles of shoreline that are considered potential for small boat marine facilities development.

The small boat harbor wet moorage needs projected for the future are shown in Table 6-10.

TABLE 6-10. Projected pleasure boating needs, Whidbey-Camano Islands

Year	Small Boat Wet Moorages Total	Net Needs[1]
Present	2,660	2,558
1980	3,770	3,668
2000	6,300	6,198
2020	10,690	10,588

[1] Cumulative needs above 102 wet moorages available in 1966.

Source: Appendix VIII, Navigation.

POWER

General

There are no hydroelectric or thermal electric generating plants located in the Islands. The Islands are served by Puget Sound Power and Light Company.

Present and Future Needs

Whidbey Island's location places it among the top sites for a potential nuclear thermal power plant. There is an abundance of offshore cooling waters and the Island is close to load centers.

Future nuclear plants would probably be constructed by private and public, non-Federal utilities. The possibility of a nuclear power plant being located in the Islands is unknown at this time. Potential sites were analyzed to develop costs and other site considerations relative to islands in Puget Sound. Island sites offer potential siting advantages in terms of lowered costs for the coolant system and ready access by marine transportation. There are excellent possibilities for nuclear-electric development with once-through cooling.

There exists a need for additional power development in the Puget Sound Area. This need has been delineated on an Area-wide basis, and therefore, further discussion is referred to the Area portion of this Appendix.

FLOOD CONTROL

The Islands have no major stream and any flood problems are more accurately a matter of ponding due to poor drainage. Accordingly, flooding is discussed under Watershed Management.

WATERSHED MANAGEMENT

General

Watershed management includes integrated programs and projects for reduction of floodwater damage and for water management, with rehabilitation and protection of watershed lands regardless of use. The implementation of these programs and projects would meet the primary objectives, improve the quality of municipal and industrial water, enhance fish and wildlife habitat and opportunities for recreation, and improve the general environment.

Present and Future Needs

The needs for watershed management are complex, and two or more practices and measures

may be required on the same area of land. Many measures and treatments become involved in integrated programs and projects. The watershed management needs for the Islands are tabulated in Table 6-11.

TABLE 6-11. Total watershed management needs, Whidbey-Camano Islands

Year	Flood Prevention[1] (acres)	Watershed Protection and Rehabilitation (acres)	Water Management Agricultural (acres)	Water Management Urban (acres)
1980	24,600	133,000	8,600	23,400
2000	24,600	133,000	14,400	23,400
2020	24,600	133,000	19,200	23,400

[1] Includes flooding on main streams.

Source: Appendix XIV, Watershed Management.

RECREATION

General

The location, mild climate, and recreational resources and opportunities make Whidbey and Camano Islands an ideal recreational area for the nearby Seattle metropolitan area. The State's outdoor recreation planning efforts have been considered during the plan formulation process. The recreation objectives can be accomplished by the continuing coordination at all levels of planning.

There are 21 publicly-administered outdoor recreation areas on the Islands and at least 11 private operators offer facilities for public use. The existing supply of developed lands is inadequate to satisfy 1960 boating, camping, swimming, and picnicking demands. The existing deficiency of available opportunities is largely due to the inability of public agencies to finance needed land acquisitions and development for outdoor recreation. The most pressing problem is that of providing additional facilities and areas to satisfy present as well as future outdoor recreation.

A situation that is making it more difficult for public agencies to acquire waterfront lands for recreational purposes is the tremendous surge in the development of housing tracts and individual vacation homes along the shoreline.

Present and Future Needs

The future water-related demand expressed in recreation days is as shown in Table 6-12.

TABLE 6-12. Present and projected water-related recreation demand, Whidbey-Camano Islands (1000's recreation days)

Year	Total	Net Needs[1]
1960	1,500	760
1980	3,000	2,260
2000	5,800	4,300
2020	10,800	9,300

[1] Cumulative increase above 740,000 recreation days satisfied by facilities existing in 1960.

Source: Appendix X, Recreation

In addition to the previously listed needs, scenic routes, waterfront access, harbors of refuge, special interest areas, interpretive facilities, buffer zones, and open spaces are needed to satisfy the recreation and environmental needs of the people.

FISH AND WILDLIFE

General

Whidbey-Camano Islands may be classified as a very limited production area for anadromous fish. This is due to the small size and limited number of spawning streams. Streamflows are primarily dependent upon surface runoff from rainfall resulting in greatly reduced summer flows.

The number of salmon produced from the Whidbey-Camano Islands drainages are too small to make a significant contribution to commercial or sport fisheries of the area, even though saltwater fishing is extremely popular throughout the adjacent marine waters. In addition to the anadromous species, sizeable quantities of marine fish and shellfish are harvested from the area by both commercial and sport interests.

Present and Future Needs

The prime limiting factor to fish production in the streams of the area is lack of adequate year-round flows. Low flow augmentation would not be feasible

due to the limited stream areas that could be benefited.

Additional pheasant habitat and hunting areas are needed and a program of public access to hunting lands would be expanded. A program of improving wildlife habitat require development to assist in maintaining wildlife populations in the face of diminishing habitat.

Better marine fish production areas and sport fishing areas are required to meet the future fish and shellfish needs. The public beaches should be restocked with shellfish species and better access to marine water are necessary. Studies for means to increase fish production in lakes and to control disease are essential.

Present and projected man-days of use for fishing and hunting are expressed in Table 6-13.

TABLE 6-13. Fish and wildlife sport and commercial needs, Whidbey-Camano Islands

		1965	1980		2000		2020	
	Unit	Total	Total	Net[1]	Total	Net[1]	Total	Net[1]
Sport Fishing								
Salmon	1000 User-Days	120	199	79	366	246	621	501
Game Fish	1000 User-Days	69	115	46	182	113	291	222
Marine Fish	1000 User-Days	3	4	1	6	3	7	4
Shellfish	1000 User-Days	15	21	6	28	13	36	21
Total		207	339	132	582	375	955	748
Hunting	1000 User-Days	55	105	51	171	116	211	156
Commercial Fishing	1000 Pounds	--	--	--	--	--	--	--

[1] Cumulative above 1965 activity.

Source: Appendix XI, Fish and Wildlife.

BASIS OF PLANNING

Desires of Local People

During the Public Hearings held in Everett on 22 October 1964, local interests overwhelmingly expressed the needs for obtaining a new source and supply of domestic water. They stated that the existing ground water supplies are limited in both quantity and quality. A firm water supply was also needed throughout the Islands for fire protection. The view was expressed that the water supplies could be imported from the Skagit, Snohomish or Stillaguamish Rivers. Needs were also expressed for land stabilization measures, additional small boat moorages, additional recreation lands and facilities and new sewage disposal systems to control land and beach contamination.

Summary of Island Needs

The needs of the Whidbey-Camano Islands for 1980, 2000 and 2020 are summarized in Table 6-14.

TABLE 6-14. Summary of needs, Whidbey-Camano Islands

Feature	Units	Cumulative Net Needs[1] 1980	2000	2020
M&I Water Supply	mgd	7.9	15.6	25.5
	(1000 Acre-Feet)	8.8	17.4	28.5
Irrigation	1000 Acre-Feet	0	0	0
Water Quality Control				
Waste	1000 Population Equivalents	85	136	181
Flow	cfs	0	0	0
Navigation				
Commercial	1000 Short Tons	0	0	0
Pleasure Boats	Wet Moorages	3,668	6,198	10,588
Power[2]				
Flood Control	$1000 Damage Reduction	0	0	0
Watershed Management				
Flood Prevention	1000 Acres	24.6	24.6	24.6
Rehabilitation and Protection of Watersheds	1000 Acres	133.0	133.0	133.0
Water Management				
Agriculture	1000 Acres	8.6	14.4	19.2
Urban	1000 Acres	23.4	23.4	23.4
Recreation	1000 User-Days	2,260	4,300	9,300
Fish and Wildlife				
Sport				
Fishing	1000 User-Days	132	375	748
Hunting	1000 User-Days	51	116	156
Commercial Fishing	1000 Pounds	0	0	0

[1] See Water and Related Land Resource Needs section for derivation of net needs.

[2] Power needs have been projected for the Puget Sound Area only.

[3] Total acreage in Islands involved in program measures.

General Planning

Since there are no streams or rivers of any magnitude on the Islands and the use of ground water is limited, the range of physical opportunities for meeting the Islands' water resource needs also are limited. However, a broad range of alternative non-storage and management opportunities were viewed in the formulation process. These included, but were not limited to, interbasin transfer, desalinization, further ground water utilization and improved water yields through various watershed management practices to satisfy water supply needs of municipalities and local commercial businesses, irrigated farming, water quality preservation and enhancement and marine and shellfish use. Agricultural and urban drainage measures, channelization of small streams, bank protection, beach erosion and improved land use management practices are considered as possible means of meeting watershed management needs. Opportunities for satisfaction of water quality needs are sewerage collection and treatment facilities. The water and related land resource was examined in terms of projected land use pattern C_2, (see Projected Land Use) with the land needs of navigation, power, recreation, and fish and wildlife in this context.

Alternative objectives were considered in developing the Comprehensive Plan. The objectives represented both ends of the spectrum of interests, i.e., economic efficiency and environmental quality as discussed in the Puget Sound Area section of this Appendix. The alternative elements considered in plan formulation are described under Alternative Elements.

The single-purpose Appendices V through XIV provided, in general, a wide array of solutions. Necessary adjustments were made in the formulation of a comprehensive plan for the Islands. Some of these adjustments were as follows:

(a) The population projections as shown in Appendix V, Water-Related Land Resources were increased for 1980, 2000 and 2020 to more clearly reflect the urban growth projected for the Area due to the expansion of the Port of Everett and Boeing Airplane Company.

(b) Because of the population expansion the water supply and water quality control plans set forth in Appendix VI, Municipal and Industrial Water Supply and Appendix XIII, Water Quality Control were altered and increased in size significantly.

SUMMARY OF PLAN

1970-2020

The early action program emphasizes construction of water supply facilities for Whidbey Island, additional treatment and sewers for both Islands, acquisition of land and construction of recreation facilities, new boat harbors and moorages, and obtaining access to areas for fishing and hunting uses.

To meet the future water supply needs for Whidbey Island, treated water would be purchased from the city of Anacortes for north Whidbey Island, and from the city of Everett for the southern part of the Island. The water for north Whidbey would be obtained near Deans Corner on Fidalgo Island and conveyed by pipeline to Whidbey Island by crossing on Deception Pass Bridge. The water would be piped to distribution centers at Oak Harbor, Coupeville, and Greenbank. The water from Everett would cross Possession Sound via the new bridge and piped to distribution centers at Clinton and Bay View.

Individual municipal distribution systems would connect to the transmission line or at the distribution centers. The distribution system costs are not included in the plan for Whidbey Island.

Camano Island's future water supply, which would be needed after 1980, would be diverted from the Stillaguamish River near Silvana and conveyed to a distribution reservoir near Kristoferson Lake on Camano Island. A water treatment plant would be included as a part of the water supply plan for Camano Island.

To comply with the Washington State water quality standards, the cities of Oak Harbor, Coupeville, Langley, and Penn Cove should provide secondary treatment facilities, disinfection facilities, and adequate marine discharge outfalls for optimum dispersion. Sewer districts would need to be established and sewers constructed throughout the Islands to intercept septic tank effluent and prevent beach and marine water contamination. Water quality surveillance is an essential element of the water quality program. Stations should be established on Camano Head, Port Susan, Gedney Island, Holmes Harbor, Crescent Harbor, Strawberry Point and Skagit Island.

There should be nine new small boat harbors established by 2020 providing over 14,300 wet moorages and 140 boat launching lanes. Three

harbors with 2,300 wet moorages should be constructed prior to 1980. These facilities would meet the needs of Whidbey and Camano Islands in addition to part of the needs of the Stillaguamish and Cedar-Green Basins.

The early action plan for watershed management includes upgrading of existing facilities and more intensive application of recurring and nonrecurring land treatment practices. Ongoing watershed management programs which provide some degree of technical assistance and financial participation would be continued. After 1980, four small watershed projects for floodwater damage prevention, rehabilitation and protection of watershed lands, and water management, would be installed, while programs would be continued and in many cases accelerated.

The recreational plan envisions facilities provided on 365 acres of lands by 1980, 1,210 acres by 2000, and 2,580 acres by 2020. To meet the needs of the 1980 recreationists would require large investments of which over one-third would be for purchasing land, principally salt water beach areas and beach access. A coordinated development plan would be established between Federal, State and local governmental bodies to acquire land and develop facilities in an orderly arrangement to meet the demands after 1980.

To meet the early action objectives of fish and wildlife would require acquisition of additional land locations throughout the Islands for public access. These lands would be in addition to those needed by recreation. Miller Lake would be enlarged for public fishing, Whidbey Island game farm would be increased in size, and a 5-acre controlled rearing impoundment would be developed for salmon production. Fish and wildlife programs to enhance shellfish production, develop marine water rearing areas, and acquire additional lands for waterfowl and upland game habitat are included.

The possibilities of a nuclear power site being located on Whidbey Island are good since it is located near the present and projected main load centers and has an abundance of offshore cooling waters. Four potential sites on Whidbey Island, each capable of supporting several power complexes, were studied. One of the areas on Whidbey Island could support at least three 2,000 mw nuclear-electric plants by the year 2000. Further studies are required that consider shoreline characteristics, nearness to major load centers and impacts on the natural environment before a final decision can be made on plant locations.

The early action plan includes programs amounting to $16,531,000 and projects costing $42,530,000 for a total investment of $59,061,000. Program and project investment costs for the 1980-2000 period amount to $64,810,000 and for the 2000-2020 period $82,876,000 for a total 50-year investment of $206,747,000.

Table 6-15 shows all elements and the attendant costs. The output of the programs are complementary to the listed project facilities.

TABLE 6-15. Comprehensive Plan, Whidbey-Camano Islands

Feature	Item	1970-1980 Investment[1] Costs ($1000)	Average Annual Costs ($1000)	Average Annual Benefits Gross ($1000)	Average Annual Benefits Net ($1000)	1980-2000 Investment Costs ($1000)	2000-2020 Investment Costs ($1000)	1970-2020 Investment Costs ($1000)
Management Programs								
Water Quality Control	Monitoring, Evaluation and Control Programs	250				200	240	690
Watershed Management	Programs	16,266				18,412	19,642	54,320
Fish & Wildlife	Programs	15				15	15	45
Total Programs		$16,531				$18,627	$19,897	$ 55,055
Nonstorage Projects								
M&I Water Supply	Ground Water Use	216	25[3]	25	0	0	0	216
	Surface Water Use	10,100	634[3]	634	0	2,500	0	12,600
Water Quality Control	Waste Treatment and Collection Facilities	3,187	208[3]	208	0	8,110	10,345	21,642
Navigation	Small Boat Harbors[2]	(4,648)	(298)	(431)	(133)	(5,355)	(18,910)	(28,913)
Watershed Management	Floodwater Damage Reduction, Water Management, Protection and Rehabilitation	0	0	0	0	3,245	0	3,245
Recreation	Land Acquisition, Access and Facilities	28,450	2,257	2,715	458	31,800	51,900	112,150
Fish & Wildlife	Production Enhancement Facilites, Access and Acquisition	577	42	484	442	528	734	1,839
Total Nonstorage		$42,530	$3,166	$4,066	$900	$46,183	$62,979	$151,692
Total Programs and Projects		$59,061				$64,810	$82,876	$206,747

1 Includes cumulative annual program costs for the period for management features and capital costs for nonstorage projects.

2 General Navigation facilities cost and benefits for small boat harbors only. Total pleasure boat facilities, costs and benefits included with Recreation.

3 Average annual benefits assumed equal to average annual costs.

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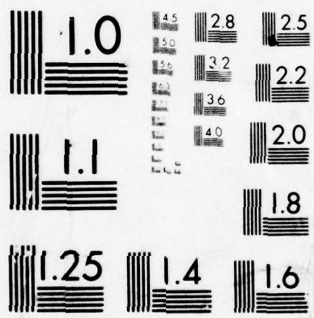

MICROCOPY RESOLUTION TEST CHART
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FEATURES OF THE COMPREHENSIVE PLAN

Municipal and Industrial Water Supply

Additional water supplies are needed prior to 1980 on Whidbey Island. Camano Island's present supply is adequate until after this time period. A continuing investment for local and municipal distribution systems would be necessary during each of the study time periods. A regional water supply system for both Whidbey and Camano Islands is considered the only practicable and economical means for meeting the future water supply demands of the Islands.

The Naval Air Station at Ault Field on Whidbey Island has its own water transmission system and obtains its needed water supplies from the city of Anacortes, located in the Skagit-Samish Basins. The system has a present capability of 2.5 mgd and the Naval Station is in the process of enlarging this system to 4.0 mgd which would be adequate to meet the year 2020 needs of the Station. The water quantities for the Naval Air Station facility are included in the water needs tabulations, but the costs for enlarging the system are not included as a part of the plan for Whidbey-Camano Islands.

1970-1980—The future water supply for Whidbey Island could be obtained by interbasin transfer from the Skagit-Samish Basins and the Snohomish Basin. The selected conveyance system for Whidbey Island would be capable of supplying the water importation requirements for the year 2020. For North Whidbey Island the water would be purchased from the city of Anacortes on Fidalgo Island and transmitted to Whidbey Island across the Deception Pass Bridge. The pipeline would traverse the length of Whidbey Island to Greenbank providing water to the individual municipalities throughout its length from the distribution centers located at Oak Harbor, Coupeville, and Greenbank. Cost studies indicated it would be more economical to purchase treated water from the city of Anacortes than to pump from the Skagit River and provide a treatment plant. The water for South Whidbey would be purchased from the city of Everett, piped across the projected new bridge, and delivered to main distribution centers located at Clinton and Bay View.

Adequate water supplies are available from the cities of Anacortes and Everett and both cities have expressed an interest in providing the water.

The city of Oak Harbor apparently has adequate ground water supplies for the near future. An assumption was made that Oak Harbor would be a part of the Island-wide water system by 1980.

The municipalities and small rural community systems would have to enlarge their distribution facilities to meet the peak day and fire control demands.

The investment and annual costs of the water systems are shown in the following tabulation:

Development	Needed by Year	1980 Average Daily Water Use (mgd)	Total System Capability (mgd)	Supply, Transmission & Investment ($1000)	Average Annual Costs: Interest & Amort.[2] ($1000)	Average Annual Costs: O&M[3] ($1000)	Average Annual Costs: Total ($1000)	Average Annual Benefits[4] ($1000)
Whidbey Island[1]	1980	10.0	21.8	10,100	472	162	634	634
Small Rural Community Systems	1975	1.7	5.0	216	10	15	25	25
Total		11.7		$10,316[1]	$482	$177	$659	$659

[1] Does not include Naval Air Station at Ault Field.

[2] Interest and amortization of capital investment costs.

[3] Total incremental increase in annual operation and maintenance costs, including pumping and treatment costs.

[4] Average annual benefits assumed equal to average annual costs.

The conveyance facilities costs include the pipeline, pump plants, substations, and regulating reservoirs. The conveyance pipelines have been sized to meet the year 2020 maximum monthly water supply demands. The regulating reservoirs are located at Oak Harbor, Prairie Center, Greenbank, Clinton and Bay View. Each reservoir was sized to hold 3 million gallons. The local municipal distribution systems would connect into these reservoirs. The local systems would consist of local service reservoirs (covered), the pipe distribution system, and household meters. The local distribution system costs are not included in this estimate.

1980-2020–Camano Island's present ground water supply is adequate until after 1980. After this date, the Island's year 2000 and 2020 water needs could be met by diversion from the Stillaguamish River near Silvana. Water would be pumped from the river and delivered to a storage and regulating reservoir between Smith and Kristoferson Lakes. A water treatment plant would be located at the pumping station on the Stillaguamish River. Water would be delivered to the individual homes through an Island-wide distribution system diverting from the regulating reservoir.

The costs of the conveyance facilities are shown in the following tabulation.

The supply and transmission facilities were sized to meet year 2020 demands.

Development	Needed by Year	2000 Average Daily Water Use (mgd)	Total System Capability (mgd)	Supply, Transmission and Treatment Investment ($1000)
Camano Island	1985	3.0	5.4	2,500
Whidbey Island[1]	--	16.4	25.8[1]	0
Small Rural Community Systems	--	--		0
Total		19.4		$2,500

[1] Includes 4.0 mgd capacity of Naval Air Station at Ault Field.

Irrigation

Irrigation development is not included as part of the Plan.

Water Quality Control

A sizeable investment would be required to meet the present and future waste collection and treatment requirements for the Islands.

1970-1980–Several elements comprise the overall plan for insuring adequate water quality in the Whidbey-Camano Islands. The major aspect of this plan is adequate waste collection and treatment facilities. Most wastes would continue to be organic, being generated primarily from Oak Harbor, the Naval installations, and other areas along the shoreline. Collection and treatment facilities would provide waste discharges acceptable to the receiving waters.

The wasteloads now being discharged require a collection and treatment system composed of several new facilities, replacement and expansion of existing plants, and adequate treatment of wastes. Such a system is outlined in the Washington State Water Quality Standards and Implementation Plan, December 1967. The separate actions required are summarized below:

Oak Harbor–Installation of secondary treatment facilities with disinfection, interception of the septic tank used to treat sewage from a portion of Oak Harbor with treatment by the city's facilities, and installation of an adequate marine outfall.

Towns of Coupeville, Langley, and the Penn Cove Sewer District–Installation of secondary treatment and disinfection facilities with adequate outfall.

Seaplane Base–Installation of secondary treatment and disinfection facilities with adequate outfalls at both the Seaplane Base and Capehart Housing.

Future wastes could, in most cases, be handled by a system of municipal treatment facilities with adequate expansion and replacement. The majority of

treated wastes should be disposed of in Admiralty Inlet for rapid and optimum dispersion.

A large number of waste treatment facilities would be required to handle the expected growth in outdoor recreation, especially for pleasure boating on the surrounding marine waters.

A water quality surveillance program for the marine water is an essential element. Stations should be established on Camano Head, Port Susan (Kayak Point), Gedney Island, Holmes Harbor, Crescent Harbor, Strawberry Point, and Skagit Island to measure the marine water characteristics on a regular basis.

The investment costs of the treatment and sewer outfall facilities and the projected program are shown in the following tabulation:

Water Quality Control
1970-1980

		Average Annual			
		Costs			
Feature	Investment Costs ($1000)	Interest & Amortization ($1000)	Operation & Maintenance ($1000)	Total ($1000)	Benefits[2] ($1000)
Monitoring, Evaluation and Control Program	250[1]				
Municipal Waste					
Treatment	1,086	56	12	68	68
Sewers	1,671	78	18	96	96
Subtotal	$2,757	$134	$30	$164	$164
Recreation	430	39	5	44	44
Total	$3,437	$173	$35	$208	$208

1 Cumulative annual program costs for the period.

2 Benefits are assumed to be at least equal to the cost.

1980-2020—During these periods expansion by light industry, and new developments and growth of urban and recreation areas correspondingly would require that new sewer interception systems be installed and treatment facilities enlarged and/or constructed. Summarized below are estimated investment costs for water quality control by sectors for each period.

Water Quality Control
1980-2020

	Investment Costs ($1000)	
Feature	1980-2000	2000-2020
Monitoring, Evaluation and Control Program[1]	200	240
Municipal		
Treatment	2,562	3,350
Sewers	4,548	5,995
Subtotal	$7,110	$ 9,345
Recreation	1,000	1,000
Total	$8,310	$10,585

1 Cumulative annual program costs for the period.

Treatment requirements would be high initially in order to comply with the State Implementation Plan. A steady annual investment would be required after 1980 to keep pace with population and recreation growth.

After 1980, recreation investment would rise to provide needed facilities and adequate treatment and a steady growth beyond 2000.

The economics of sewer system construction and the intermittent population concentrations along the shorelines of Whidbey and Camano Islands favor the formation of a number of sewer districts to meet sewage disposal needs. A coordinated approach to pollution problems should be made by the county, communities, and special districts, in order to decrease the burden of financing treatment and disposal facilities and to spread the tax base throughout the Islands.

With the construction of approximately 14,350 small boat wet moorages, considerable wastes would be generated at the small boat harbors. The local government should recognize the potential water quality degradation threat and implement restrictive controls prior to construction.

Navigation

The Islands' unique shoreline, with its numerous coves and harbors, lends itself towards development of small boat harbor facilities. The Islands' offshore waters offer excellent fishing. Providing additional boating wet moorages, launching ramps and access would enhance this recreational opportunity.

1970-1980—The increased demand for small boat moorages could necessitate construction of at least three small boat harbors by 1980. Locations at Langley, Point Partridge and Oak Harbor are considered suitable for development of public moorages. Oak Harbor would be developed in two stages with the first stage providing 500 wet moorages.

The small boat construction sequence as projected is considered only tentative as many factors enter into small boat harbor developments with impacts beyond the capability of the planner to foresee. The construction costs and average annual costs and benefits of the public small boat harbor projects tentatively scheduled for construction by 1980 are tabulated below:

Small Boat Harbor Projects
1970-1980

Location	Wet Moorages	Invest. Costs ($1000)	Average Annual[1] Costs ($1000)	Average Annual[1] Benefits ($1000)
Oak Harbor—Phase I	500			
Langley	500			
Point Partridge[2]	1,300			
Total	2,300	$4,648	$298	$431

[1] Total pleasure boat facilities costs and benefits are contained in Recreation. These are included here for information purposes.

[2] This site ideally located to serve as harbor of refuge.

The small boat harbor projects would probably be built by public agencies due to the high construction costs. Some of the natural harbors, inlets and bays can be developed by private investment. About 1,370 wet moorages are planned for construction by the private sector to satisfy summer moorage requirements.

1980-2020—The total wet moorages shown for the 1980 projects include provisions for winter moorage only. The number of federally-financed wet moorages shown in the plan for 2000 and 2020 exceed the needs for Whidbey and Camano Islands only. This overage is planned to partly relieve the projected shortages due to lack of adequate sites in the Stillaguamish and Cedar-Green Basins. The small boat harbor developments for the 1980-2020 period are shown in the following tabulation:

Small Boat Harbor Locations	2000 Wet Moorages	2000 Invest. Cost ($1000)	2020 Wet Moorages	2020 Invest. Cost ($1000)
Oak Harbor–Phase II	1,660			
Skagit Bay–Utsalady I	1,000			
Subtotal	2,660	$5,355		
Skagit Bay–Utsalady II			1,050	
Cultus Bay			2,050	
Useless Bay–Maxwelton			1,370	
Penn Cove–Coupeville			1,540	
Skagit Bay–Dugualla Bay			1,540	
Port Susan–Camanols			1,840	
Subtotal			9,390	$18,910
Cumulative Total above present development	6,328		14,350	$28,913

With the sequence of development as shown, and assuming the private sector developing 1,368 wet moorages, there would be an overage of 130 wet moorages by year 2000 and 5,130 by year 2020. These would meet the unsatisfied demand from the populous Cedar-Green Basins.

The small boat lands and facilities costs and benefits are carried under Recreation. The salt water small boat harbors are shown here for informational purposes.

Power

There are no electric power generating facilities projected for the early action program. To meet the future energy requirements, nuclear generating plants would be required at a number of locations in the Puget Sound Area during the next 50 years.

The large and cold offshore currents on the western side of Whidbey Island provide the potential for development of nuclear power generation facilities. The warmer cooling waters could be beneficial to the swimming beaches and the many forms of plant and animal life native to the area. Diversion of cooling water from the eastern side of Whidbey, with passage through the generating plant and discharge into the western side, could provide a better circulation of water in nearly enclosed bays such as Penn Cove and Holmes Harbor. Most of the plants are expected to be located along the saltwater shoreline and utilize offshore water for cooling. Further site studies are needed before any plant site locations are determined.

At least three 2,000 mw plants are expected to be eventually located on Whidbey Island. Costs for a nuclear power generating plant, including land, are estimated to be about $200 per kilowatt. The cost for each 1,000 mw plant would be about $200,000,000.

Nuclear power sites generally require a minimum of about 350 acres of land per 1,000 mw plant on a waterfront site for buffer purposes. The total land requirements for six 1,000 mw plants would be about 2,100 acres. However, multiple-unit plants would require much less land. The physical plant would occupy only a few acres of this total and the remainder can be compatibly used for almost any daytime use purpose such as parks and picnic areas.

As construction of a nuclear plant for Whidbey is not projected until after 1980, there exists sufficient time to develop a comprehensive recreational or other use plan utilizing these areas.

Further discussion on nuclear power generation is included in the Area section of this Appendix.

Flood Control

There are no flood problems in the Islands due to the lack of major streams.

Watershed Management

Watershed management programs, particularly in the newer urban development areas, could effectively reduce erosion as a sediment source. Beach erosion can be contained with specific control measures, some structural and some management. Each beach erosion area is generally unique in itself and must be analyzed separately.

The development of resources on the Islands would require a watershed management program designed to reduce floodwater damage, rehabilitate and protect the watershed areas, and provide water management for a variety of purposes on rural and urban lands.

A combination of structural and nonstructural measures are required to accomplish these purposes. Representative measures are described in detail in Appendix XIV, Watershed Management. While the acreage requiring treatment remains fairly constant by time periods, the intensity of treatment application and the composition of the combined measures varies with the inherent capability of the land, as well as with the kind and intensity of use. Benefits from proper application of these measures are increased production, protection from watershed deterioration, forest fire protection and enhancement of many environmental qualities.

1970-1980—The early action program consists entirely of land treatment measures to accomplish specific objectives for conservation and development.

Federal and State land administrative agencies are responsible for the installation of applicable measures on land assigned to their management, while the initiative of individual property owners is required for installation of practices on lands in private ownership. Various Federal and State agencies have programs of technical and financial assistance for individuals, local organizations, and subdivisions of government. The program measures for the early action plan are:

Watershed Management
1970-1980

Program	Area (acres)	Costs ($1000)
Technical assistance		
and management	109,529	
Federal, regular		1,117
Federal, accelerated		0
Subtotal		$ 1,117
Installation of practices		
(non-Federal)		
State and corporate		1,124
Land treatment	107,075	1,969
Water management		
Agricultural	8,632	1,523
Urban	7,802	10,533
Subtotal		$15,149
Total		$16,266

Beach erosion problems on Whidbey and Camano Islands are discussed under the Puget Sound Area.

1980-2000—Due to population expansion and the need for a higher degree of management and protection, the program would be accelerated after 1980 by the installation of specific watershed projects to reduce flood and sediment damages, improve water management and provide rehabilitation and protection to the watershed lands. Ongoing program measures would be continued, and in some cases accelerated. The program costs, project locations and installation costs are shown in the following tabulation:

Watershed Management
1980-2000

Program	Area (acres)	Costs ($1000)
Technical assistance		
and management	109,529	
Federal, regular		1,553
Federal, accelerated		71
Subtotal		$ 1,624
Installation of practices		
(non-Federal)		
State and corporate		1,498
Land treatment	107,075	2,625
Water management		
Agricultural	10,550	2,566
Urban	7,481	10,099
Subtotal		$16,788
Total		$18,412

Projects	Area (acres)	Structural Measures Installation Costs ($1000)
Whidbey Island		
North Island	40,472	1,300
Central Island	30,310	800
South Island	36,889	770
Camano Island	25,264	375
Total	132,935	$ 3,245

2000-2020—The programs needed to meet the watershed management needs during this time period are shown in the following tabulation:

Watershed Management
2000-2020

Program	Area (acres)	Costs ($1000)
Technical assistance		
and management	109,529	
Federal, regular		1,553
Federal, accelerated		0
Subtotal		$ 1,553
Installation of practices (non-Federal)		
State and corporate		1,498
Land treatment	107,075	2,625
Water management		
Agricultural	5,000	3,000
Urban	8,123	10,966
Subtotal		$18,089
Total		$19,642

There is a continuing investment needed, both public and private, to insure the protection of the water and related land within the Islands under projected development. This investment would be made in the form of financial assistance, technical assistance, research, education and information, and general management of the resource by the public agencies. Private investment would be contained in the foregoing programs and in the final accomplishment of the specific project measures.

Recreation

The Islands provide an outstanding environment for recreation and a base for salt water fishing and other outdoor activities. Their extensive shorelines and excellent beaches, resorts, pleasant roads, charming towns and older buildings, historic sites, large Naval installations at Ault Field and Oak Harbor and the spectacular Deception Pass attract many visitors. In addition, the favorable climate is attractive to recreationists. The 221 miles of salt water shoreline, lakes and forested lands can fully support an expansion of recreational developments. Additional campgrounds, picnic areas, beaches, and public access are planned for the Islands. The recreation development would be coordinated with the State of Washington Recreation Plan at all stages of development.

The Islands have significant types and amount of year-round recreation areas. The primary needs are of acquiring lands and public access, and developing recreational facilities for public usage. However, some areas in the Islands should be retained in their present natural state for use by future generations.

The broad recreation goal is to promote well-planned development and protection of the existing resources, and to provide an opportunity for the satisfaction of present and future outdoor recreation demands of the population. Based on ownership of land, plans and programs of recreation suppliers, and expected population concentrations as well as outdoor recreation needs, the assumption is made that the State agencies would provide 45 percent of the future required water-related opportunities, while the county and local agencies and the private sector would supply 30, and 25 percent, respectively.

To satisfy part of the recreational demands, the following lands and water areas are required:

Recreation Land and Water Requirements
1960-2020

		1960		1980		2000		2020	
Activity	Unit	Land	Water	Land	Water	Land	Water	Land	Water
Swimming									
Natural waters	Acres	11	2	31	4	66	9	126	19
Pools	Sq. Ft.	1,400	1,200	7,400	4,200	18,400	9,200	38,400	14,200
Boating, sailing, and water skiing	Acres	31	--	86	--	196	--	406	--
Camping	Acres	170	--	380	--	880	--	1,780	--
Picnicking	Acres	75	--	155	--	355	--	555	--
Hiking	Miles	35	--	80	--	150	--	290	--

Source: Appendix X, Recreation.

A similar amount of land acreage in low density use would be necessary as a buffer around the developed recreation areas.

1970-1980–During this period the acquisition of an additional 652 acres and the development of camping, picnicking, and other recreation facilities would be accomplished.

The recreational developments include interior roads, sanitation facilities, water supply, parking areas, access areas, etc. The recreation areas which would be given consideration are shown on Figure 6-3.

The primary need of recreation is salt water access and beach areas. Approximately two-thirds of Whidbey Island's tidelands are State owned and administered by the Department of Natural Resources. Only a small portion of the tidelands around Camano Island are owned by the State. These tidelands should be retained in public ownership since they are of significant value in satisfying recreation demands. Better access should be provided to these tidelands which are of importance for activities such as beachcombing, swimming, and shellfish gathering.

Steep shoreline bluffs are common on the Islands. In many cases, the topography prevents shoreline housing development, but the beach area itself is sandy and quite usable for public recreation. Public agencies need to acquire scenic-access shoreline easements. These can be used jointly with the tidelands owned by the State. Such a program would be appropriate on those beach areas bounded by steep bluffs. Convenient access to the easements should be provided.

There are numerous charming country roads throughout the Islands, especially on Whidbey Island. A network of scenic roads could be designated to provide travel links between recreation attractions and to enhance the opportunities for those who enjoy driving for pleasure and sightseeing. State-wide and local systems of scenic roads can be established utilizing existing primary and secondary roads. In certain locations, additional roads could be constructed to provide better views of, and access to, the shorelines. Roadside recreation facilities are necessary along the routes, and the scenic corridors adjacent to the roads should be maintained in an attractive manner. Most Island roads should be maintained as rural, slow speed routes to encourage leisurely travel. In some cases the development of hiking and riding trails within the roadside zone of some scenic roads would be advantageous.

About 100 miles of motor vehicles routes have been proposed as scenic routes. These include Route 525 on Whidbey Island, Route 113 from Route 525 to the Keystone Ferry, the road around Camano Island, and the ferry from Keystone to Port Townsend.

Investments for recreation facilities are tabulated below:

Outdoor Recreation Improvements
Present-1980

Improvements	Investment Costs ($1000)	Average Annual Costs: Interest & Amortization ($1000)	Average Annual Costs: Operation & Maintenance ($1000)	Average Annual Total ($1000)	Average Annual Benefits ($1000)
Campgrounds	5,320				
Picnic areas	525				
Trails	480				
Beaches	372				
Swimming pools	105				
Boating facilities	7,838				
Planning and design	3,660				
Subtotal	$18,300				
Land acquisition including buffer	10,150				
Total	$28,450	$1,724	$533	$2,257	$2,715

The developments for 1980 would be capable of meeting the 1980 demands including the unmet demand of 760,000 user-days from 1960.

1980-2020–During this period additional land would be obtained and recreational facilities developed. The thermal-nuclear generation plants which may be constructed on Whidbey Island require about 350 acres of land area for each 1,000 mw plants. The physical plant occupies only a few acres of this total and the remainder could be developed into a compatible daytime recreation facility.

A tremendous surge in the development of housing tracts and individual vacation residences along the choice shoreline is projected during this time period. Waterfront and beach areas for public recreation use should be acquired early in this period.

The total estimated costs for the water-related recreational lands and facilities in the Islands during the period are:

Year	Investment Costs ($1000)
2000	31,800
2020	51,900
Total	$83,700

Fish and Wildlife

The Islands' marine waters support heavy commercial fisheries for salmon, marine fish, and shellfish. Its streams produce few resident or anadromous fish. However, the closely associated marine waters lie directly in the migration routes of anadromous fish destined to spawn in the major Puget Sound drainages. This strategic positioning makes these waters a favorite of both commercial and sport salmon fishermen.

Sport fishing for salmon, marine fish, and shellfish is heavy throughout most of the Islands. Each year additional sport fishing pressure occurs with particularly heavy pressure during the years of the pink salmon runs.

1970-1980–Due to the lack of streams on either Whidbey or Camano Island, there is limited opportunity for accomplishing additional production of anadromous fish in this area. Acquiring additional public access at both marine and fresh water areas to permit additional angler success is the primary need and consideration in the early action program. Obtaining the salt water beach areas would permit greater public utilization of the large shellfish resource. An expanded program of stocking fish in fresh lakes would be necessary to retain favorable catch ratios. Enlarging Miller Lake would create additional fresh water fishing areas. Enlarging the game farm on Whidbey Island would be required to satisfy the future game bird hunting demand.

Dungeness crabs are distributed along the shorelines with the most productive waters located in the southern portion adjacent to the deeper channels. Public beach access and new management programs would enhance the harvest of these species.

The projects and programs for the early action period are:

Fish and Wildlife
Projects and Programs
Prior to 1980

Projects

a. Obtain salt water rearing area.
b. Obtain lake enlargement–Miller Lake.
c. Obtain salt water access at Greenbank Beach.
d. Obtain salt water access at Bush Point.
e. Obtain salt water access at Lagoon Point.
f. Obtain salt water access at Land Point Manor.
g. Obtain fresh water access at Silver Lake.
h. Develop portions of salt water access areas for waterfowl observation and hunting.
i. Increase production of Whidbey Island game farm.
j. Acquire easements for wildlife habitat improvement and hunting access.

Programs

k. Develop educational program on the wise use of the wildlife resource.
l. Implement lake fertilization study.
m. Develop a clam hatchery for restocking public clam beaches.

The public access areas noted are in addition to the access areas carried in the recreation plan. The costs and associated benefits for the aforementioned fish and wildlife projects and programs are shown in the following tabulation.

Fish and Wildlife
Project and Program Costs
1980

Year	Project or Program	Initial Investment ($1000)	Average Annual Costs: Interest & Amortization ($1000)	Average Annual Costs: Operation & Maintenance ($1000)	Average Annual Costs: Total ($1000)	Average Annual Benefits: Total ($1000)
1970-1980	Project	577	24	17	41	301
	Program	15	--	1	1	183
Total		$592	$24	$18	$42	$484

1980-2020—The projects and programs during these periods would consist of providing access to hunting grounds and fishing areas and obtaining key wildlife and wildfowl habitat areas.

Local programs for enhancement of fish and wildlife presently being conducted would be continued.

The year 2000 and 2020 investment costs would be:

Project or Program	Investment ($1000)
2000	
Projects	528
Programs	15
Total	$543
2020	
Projects	734
Programs	15
Total	$749

COST-BENEFIT SUMMARY

The program and investment costs by resource feature are shown in Tables 6-16 and 6-17 with the costs distributed between Federal, State, local, and private interests. Average annual costs and benefits are shown for the projects recommended for implementation prior to 1980. Interest and amortization costs are based on a 100-year economic life with appropriate allowances made for major replacements. An interest rate of 4-5/8 percent was used in the economic analysis. Benefits for municipal and industrial water supply and water quality improvement were assumed equal to annual charges.

TABLE 6-16. Program investment costs,[1] Whidbey-Camano Islands ($1000)

		Government			
Feature	Private	Local	State	Federal	Total
			1970-1980		
Water Quality Control	45	45	110	50	250
Watershed Management	9,050	5,267	832	1,117	16,266
Fish and Wildlife	0	0	15	0	15
Subtotal	$ 9,095	$ 5,312	$ 957	$1,167	$16,531
			1980-2000		
Water Quality Control	32	32	94	42	200
Watershed Management	10,629	5,050	1,109	1,624	18,412
Fish and Wildlife	0	0	15	0	15
Subtotal	$10,661	$ 5,082	$1,218	$1,666	$18,627
			2000-2020		
Water Quality Control	40	40	112	48	240
Watershed Management	11,497	5,483	1,109	1,553	19,642
Fish and Wildlife	0	0	15	0	15
Subtotal	$11,537	$ 5,523	$1,236	$1,601	$19,897
Total	$31,293	$15,917	$3,411	$4,434	$55,055

[1] Cumulative annual program costs over the period.

TABLE 6-17. Project investment costs[1] and cost-benefit summary, Whidbey-Camano Isands ($1000)

Feature	Investment Costs					Average Annual Costs			Annual Benefits	
		Government								
	Private	Local	State	Federal	Total	Interest & Amortization[2]	Operation & Maintenance	Total	Total	Net
		1970-1980								
M&I Water Supply	0	10,316	0	0	10,316	482	177	659	659	0
Irrigation	0	0	0	0	0	0	0	0	0	0
Water Quality Control	0	1,379	689	1,119	3,187	173	35	208	208	0
Navigation[3]	0	0	0	0	0	0	0	0	0	0
Flood Control	0	0	0	0	0	0	0	0	0	0
Watershed Management[4]	0	0	0	0	0	0	0	0	0	0
Recreation	7,100	8,550	12,800	0	28,450	1,724	533	2,257	2,715	458
Fish and Wildlife	0	0	577	0	577	24	18	42	484	442
Subtotal	$ 7,100	$20,245	$14,066	$1,119	$ 42,530	$2,403	$763	$3,166	$4,066	$900
		1980-2000								
M&I Water Supply	0	2,500	0	0	2,500					
Irrigation	0	0	0	0	0					
Water Quality Control	0	3,555	1,778	2,777	8,110					
Navigation[3]	0	0	0	0	0					
Flood Control	0	0	0	0	0					
Watershed Management[4]	0	1,136	0	2,109	3,245					
Recreation	1,950	9,550	14,300	0	31,800					
Fish and Wildlife	0	0	528	0	528					
Subtotal	$ 7,950	$16,741	$16,606	$4,886	$ 46,183					
		2000-2020								
M&I Water Supply	0	0	0	0	0					
Irrigation	0	0	0	0	0					
Water Quality Control	0	4,673	2,336	3,336	10,345					
Navigation[3]	0	0	0	0	0					
Flood Control	0	0	0	0	0					
Watershed Management[4]	0	0	0	0	0					
Recreation	13,000	15,500	23,400	0	51,900					
Fish and Wildlife	0	0	734	0	734					
Subtotal	$13,000	$20,173	$26,470	$3,336	$ 62,979					
Total	$28,050	$57,159	$57,142	$9,341	$151,692					

1 Capital project costs.

2 Of initial investment and major replacement.

3 Costs and benefits for pleasure boating moorage facilities included with Recreation.

4 Installation of structural measures only.

SEQUENCE OF DEVELOPMENT

The projects and programs of the Comprehensive Plan are summarized in Table 6-18 by time period. The project numbers identify features on Figure 6-3.

TABLE 6-18. Future projects and programs, Whidbey-Camano Islands

PROJECTS PRIOR TO 1980

Project No.

Municipal and Industrial Water Supply

1. Construct water supply pipeline for north Whidbey Island from Deans Corner to Greenbank.
2. Construct water supply pipeline for south Whidbey Island from the city of Everett to Bay View.
3.* Enlarge the small and rural community municipal and water supply transmission systems.

Water Quality Control

4. Provide secondary treatment facilities with disinfection, and an adequate outfall at Oak Harbor.
5. Provide secondary treatment and disinfection facilities with adequate outfall at the Seaplane Base near Oak Harbor.
6. Provide secondary treatment and disinfection facilities with adequate outfall at Coupeville, Langley and the Penn Cove Sewer District.
7.* Improvement of waste collection facilities for recreation developments including small boat harbors.

Navigation

8. Small boat harbor development–Oak Harbor, Phase I.
9. Small boat harbor development–Point Partridge.
9a. Small boat harbor development–Langley.

Recreation

10. Development of a beach recreation site north of Dugvalla Bay.
11. Development of an urban recreation area at Oak Harbor.
12. Development of two recreation areas in Penn Cove.
13. Development of a beach recreation area south of Coupeville.
14. Development of a beach recreation area in Admiralty Bay.
15. Development of a beach recreation area near Greenbank.
16. Development of a beach recreation area near Brush Point.
17. Development of a beach recreation area in Mutiny Bay.
18. Development of two beach recreation areas near Langley.
19. Development of a recreational area near Lone Lake.
20. Development of a recreational area near Deer Lake.
21. Development of a recreational area at Cultus Bay.
22. Development of a recreation area near Utsaladdy, Camano Island.
23. Development of a beach recreation site near Triangle Cove, Camano Island.
24. Development of a beach recreation site near Elger Bay, Camano Island.
25. Development of a beach recreation site near Camano Head, Camano Island.

Fish and Wildlife

26. Acquire and develop saltwater access near Greenbank Beach.
27. Acquire and develop saltwater access near Bush Point.
28. Acquire and develop saltwater access near Lagoon Point.
29. Acquire and develop saltwater access near Land Point Manor.
30. Acquire and develop fresh water access at Silver Lake.
31. Enlarge Miller Lake.
32.* Develop a salt water rearing area.
33.* Increase size of Whidbey Island game farm.

PROGRAMS PRIOR TO 1980

Water Quality Control

a.* Establish and operate water quality surveillance stations at key salt and fresh water locations and prepare comprehensive sewerage plan for the Islands.

Watershed Management

b.* Provide technical assistance and management for State and Federal lands.
c.* Provide technical assistance for on-farm and other private practices.

Fish and Wildlife

d.* Conduct lake fertilization studies.
e.* Educational programs on the use of wildlife resources.
f.* Perform an inventory of shellfish stocks and recreational use of tidelands.
g.* Acquire title or easements to land for wildlife habitat development and hunter access.

*Project or program not shown on Figure 6-3.

TABLE 6-18. Future projects and programs, Whidbey-Camano Islands (Cont'd)

PROJECTS 1980-2000

Municipal and Industrial Water Supply

34. Construct the water supply pipeline from Stillaguamish River to Camano Island.

Water Quality Control

35. Enlarge and expand waste treatment and sewer facilities at Oak Harbor, Coupeville, Langley, Greenbank and Clinton.
36.* Provide waste treatment facilities at recreation developments and small boat harbors.

Navigation

37. Enlargement of small boat harbor development at Oak Harbor.
38. Construct small boat harbor development at Utsalady.

Watershed Management

39. Small watershed multiple-purpose project –North Whidbey Island.
40. Small watershed multiple-purpose project –Central Whidbey Island.
41. Small watershed multiple-purpose project –South Whidbey Island.
42. Small watershed multiple-purpose project –Camano Island.

Recreation

43. Development of a recreation area near Silver Lake.
44. Development of two recreation areas near Crescent Harbor.
45. Development of a beach recreation area near Penn Cove.
46. Development of a beach recreation area near Race Lagoon.
47. Development of two beach recreation areas near Greenbank.
48. Development of a beach recreation area near Bush Point.
49. Development of a beach recreation area near Mutiny Bay.
50. Development of a beach recreation area near Lone Lake.
51. Development of two beach recreation areas on east side Camano Island.
52. Development of one beach recreation area near Triangle Cove–Camano Island.
53. Development of one beach recreation area on Camano Island.
54. Development of two beach recreation areas on east side Camano Island.

Fish and Wildlife

55.* Develop additional access areas and habitat areas.

PROGRAMS 1980-2000

Water Quality Control

h. Continue water quality monitoring, evaluation and control programs.

Watershed Management

i. Provide technical assistance for on-farm and other private practices.
j. Provide technical assistance and management for State and Federal lands.

Fish and Wildlife

k. Continue fish and wildlife programs.

PROJECTS 2000-2020

Water Quality Control

56. Enlarge and expand waste treatment facilities at Oak Harbor, Coupeville, Greenbank, Langley and Clinton.
57.* Provide waste treatment facilities at recreation developments and small boat facilities.

Navigation

58. Enlargement of the small boat harbor development–Utsalady.
59. Development of a small boat harbor–Camanols.
60. Development of a small boat harbor–Dugualla Bay.
61. Development of a small boat harbor–Coupeville.
62. Development of a small boat harbor–Useless Bay.
63. Development of a small boat harbor–Cultus Bay.

Recreation

64. Development of three beach recreation sites south of Ault Field.
65. Development of three beach recreation sites near Crescent Harbor.
66. Development of three beach recreation sites near Penn Cove.
67. Development of three beach recreation sites near North Bluff.
68. Development of three beach recreation sites near Lagoon Point.
69. Development of three beach recreation sites near Stanwood.
70. Development of three beach recreation sites near Elger Bay.

*Project or program not shown on Figure 6-3.

TABLE 6-18. Future projects and programs, Whidbey-Camano Islands (Cont'd)

Fish and Wildlife

71.* Continue developing access, marine fish facilities and habitat areas.

PROGRAMS 2000-2020

Water Quality Control

l. Continue water quality monitoring, evaluation and control programs.

Watershed Management

m. Provide technical assistance for on-farm and other private practices.

n. Provide technical assistance and management for State and Federal lands.

Fish and Wildlife

o. Continue fish and wildlife programs.

*Project or program not shown on Figure 6-3.

PLAN ACCOMPLISHMENTS

Accomplishments of the Comprehensive Plan toward meeting identified multiple-purpose needs in the Islands are summarized in Table 6-19.

The needs for the Islands, except for irrigation, wildlife, and, to some degree, fish, can all be met.

The irrigation water supply needs cannot be met from ground water because of inadequate supplies or from imported surface supplies because of the high cost of conveyance. The present level of irrigation is expected to be maintained using ground water as the source of supply. Some small catchment ponds may be developed to capture precipitation runoff, but these would provide irrigation water supplies adequate for only small acreages.

The wildlife and subsequent hunting demands of the Islands cannot be met due to the projected decreasing amounts of wildlife habitat and the greater hunting pressure which would be applied to them.

TABLE 6-19. Comprehensive Plan, accomplishments, Whidbey-Camano Islands

Feature	Units	1970-1980			1980-2000			2000-2020		
		Needs	Accomp.	Residual	Needs	Accomp.	Residual	Needs	Accomp.	Residual
M&I Water Supply	mgd	7.9	7.9	0	15.6	15.6	0	25.5	25.5	0
	(1000 Acre-Feet)	8.8	8.8	0	17.4	17.4	0	28.5	28.5	0
Irrigation	1000 Acre-Feet	0	0	0	0	0	0	0	0	0
Water Quality Control										
Waste	1000 Population Equivalents	85	85	0	136	136	0	181	181	0
Flow	cfs	--	--	--	--	--	--	--	--	--
Navigation										
Commercial	1000 Short Tons	--	--	--	--	--	--	--	--	--
Pleasure Boats	Wet Moorages	3,668	2,300	1,368[3]	6,198	6,328	(130)[4]	10,588	14,350	(5,130)[4]
Power[1]										
Flood Control	Damage Reduction ($1000)	0	0	0	0	0	0	0	0	0
Watershed Management										
Flood Prevention	1000 Acres	24.6	24.6	0	24.6	24.6	0	24.6	24.6	0
Rehabilitation and Protection of Watersheds[5]	1000 Acres[2]	133	133	0	133	133	0	133	133	0
Water Management[6]										
Agricultural	1000 Acres	8.6	8.6	0	14.4	14.4	0	19.2	19.2	0
Urban	1000 Acres	23.4	7.8	15.6	23.4	15.3	8.1	23.4	23.4	0
Recreation	1000 User-Days	2,260	2,260	0	4,300	4,300	0	9,300	9,300	0
Fish and Wildlife										
Sport										
Fishing	1000 User-Days	132	132	0	375	375	0	748	748	0
Hunting	1000 User-Days	51	51	0	116	116	0	156	156	0
Commercial Fishing	1000 Pounds	0	0	0	0	0	0	0	0	0

1 Power Needs and Accomplishments projected for the Puget Sound Area only.

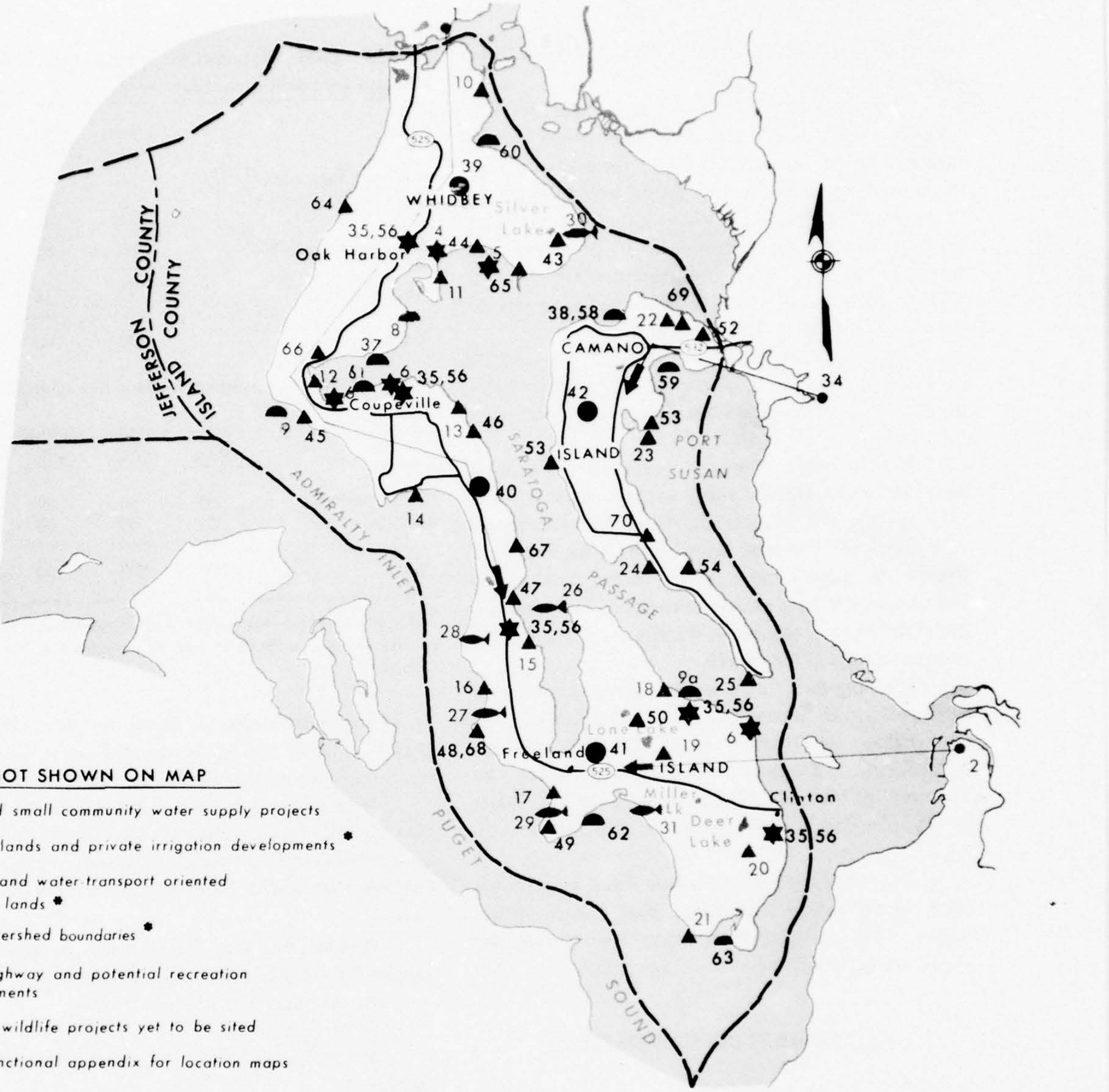
2 The necessary level of management is assumed to be established throughout the Islands, otherwise some residual could occur.

3 Residual wet moorage needs assumed to be satisfied by private development.

4 Surplus wet moorages provided to satisfy spillover need from Cedar-Green Basins.

5 The necessary level of management is assumed to be established throughout the Islands, otherwise some residual could occur.

6 Needs and accomplishments are cumulative.



ITEMS NOT SHOWN ON MAP

Rural and small community water supply projects

Irrigable lands and private irrigation developments *

Terminal and water transport oriented industrial lands *

Small watershed boundaries *

Scenic highway and potential recreation river segments

Fish and wildlife projects yet to be sited

* *See functional appendix for location maps*

LEGEND

Proposed early-action projects	FEATURE	Proposed long-range projects
	M & I Water Supply	
	Irrigation	
	Water Quality Control	
	Navigation	
	Power	
	Flood Control	
	Watershed Management	
	Recreation	
	Fish & Wildlife	
	Dam and Reservoir	

Scale in Miles

5 0 5 10

WHIDBEY—CAMANO ISLANDS

FIGURE 6-3. Comprehensive Plan elements

Some hunting demands after 1980 would have to be met in other basins.

The needs for fish are adequately met for 1980 with an excess of 39,000 angler-days which can be extended to meet year 2000 needs. Lacking perennial fresh water streams on either Island limits the ability to enhance fish production. A long-range program for fish enhancement without an adequate water resource would be of little value. Consequently, the fish and wildlife plan would require updating frequently to keep abreast of short-range demands.

An excess of 5,130 wet moorages would be provided in year 2020. These can be used to satisfy the unmet needs of the Cedar-Green Basins for that time period.

The selected plan sets forth an economical solution to the Islands' water supply needs. While it may or may not be desirable from Island County's viewpoint to contract with both Anacortes and Everett to supply their future water needs, this alternate is the least expensive method. The system is desirable from a reliability standpoint, having three sources supplying the Islands.

Planning of a future water supply system must be keyed into or in conjunction with the construction of a bridge to Whidbey Island. Without a bridge connection, Whidbey's population cannot be expected to exceed 80,000 by year 2020. Water supply planning would have to be adjusted accordingly.

Acquiring the salt water beach and recreational areas would satisfy one of the most critical recreational needs of Whidbey-Camano Islands and the Puget Sound Area.

ALTERNATIVE ELEMENTS

Water Supply Alternatives

To develop a municipal water supply study in a meaningful manner, it was necessary to make a projected population distribution throughout the Islands. The distribution is based upon intensive land use trends as projected by the Land Usage Committee. The results are shown in Table 6-20.

TABLE 6-20. Population distribution, Whidbey-Camano Islands (percentile)

Area	1980	2000	2020
North Whidbey Island[1]	50	45	35
South Whidbey Island	35	40	45
Total Whidbey Island	85	85	80
Camano Island	15	15	20
Total	100	100	100

The distribution within Whidbey Island is as follows:

Area	Present (86%)	1980 (85%)	2000 (85%)	2020 (80%)
North Whidbey[1]	68	60	50	40
South Whidbey	32	40	50	60
Total	100	100	100	100

[1] These figures do not include Ault Field Naval Air Station as the Naval Air Station has an adequate water supply system.

The distribution is based on the assumption that a bridge would be constructed in the near future from the mainland to the southern part of the Island.

In developing the water supply Plan there were two alternatives investigated. Alternative 6-A evaluated water supply through importation while Alternative 6-B evaluated a water supply through desalinization.

Alternative 6-A—Costs and benefits were prepared for delivering a water supply for:

(a) Municipal and industrial only

(b) Irrigation only

(c) Municipal and industrial and irrigation combined.

The sources of water supply from adjacent Basins and different alternative importation routes to both Islands were investigated. The alternate routes were as follows:

Whidbey Island

Route A—Source from city of Anacortes serving all of Whidbey Island.

Route B—Source from city of Everett serving all Whidbey Island (bridge crossing).

Route B-1—Same as B except crossing by submerged pipeline.

Route C—Source from both Anacortes and Everett with each serving half of the Island (bridge crossing).

Route C-1—Same as C except crossing of Possession Sound by submerged pipeline.

Camano Island

Route D—Source from Stillaguamish.

Route E—Source from Anacortes via Oak Harbor.

Additional estimates for a water supply pipeline were prepared for importing irrigation water from Anacortes to a 10,000-acre area lying between Oak Harbor and a point just south of Coupeville. The estimates were for both a single-purpose irrigation water supply pipeline and a combined irrigation municipal and industrial pipeline (Route A). A sprinkler-type irrigation distribution system was included in the estimate.

A summary of the water supply costs for the Islands is shown in Table 6-21.

The costs do not include the cost of water treatment or the cost of purchasing water from the city of Anacortes or the city of Everett.

As can be noted the irrigation benefits are not sufficient to justify construction of the necessary facilities. Therefore, irrigation was not considered further as a function of the Plan for the Islands.

The water supplies in each of the adjacent river basins are adequate in quantity and quality and it is assumed that the cost of purchasing the treated water at Everett or Anacortes would be approximately the same. The cities of Anacortes and Everett have both expressed to Island County a willingness to supply the water needs for Whidbey Island.

The routes from Everett were expanded to show costs for both a bridge crossing and a submerged pipeline crossing. In selecting the alternative route, a primary consideration was establishing approximately when a bridge would be constructed at the southern end on Whidbey Island. The water supplies are needed now. However, it was determined that under either circumstance, whether bridge or submarine crossing, the route from Everett and Deans Corner was the least expensive of all the alternatives. Therefore, Route C was selected due to its lower cost.

Alternative 6-B—The objective of Alternative 6-B was to evaluate the possibility of providing a water supply to the Islands through desalinization. The conversion of sea water to a potable supply for municipal and agricultural use has received considerable attention in recent years. Attention has been

TABLE 6-21. Cost summary water supply, Whidbey-Camano Islands

	Total	Annual Costs				Annual	Net
	Investment	Investment[1]	OM&R	Power[2]	Total	Benefits[4]	Benefits
Whidbey M&I							
Route A	15,000	701	76	197	974	634	340
Route B	12,400	580	56	137	773	634	139
Route B-1	16,600	776	40	92	908	634	274
Route C	10,100	472	70	92	634	634	0
Route C-1	13,400	627	56	65	748	634	114
Camano M&I							
Route D	2,500	117	15	19	151	151	0
Route E	4,400	206	2	11	219	151	68
Whidbey M&I Plus Irrigation							
S-P Irrigation	29,300	1,370	120	80[3]	1,570	400	-1,170
Irrigation and M&I	40,000	1,870	161	120[3]	2,151	1,034	-1,117

1 4-5/8 percent, 100 years.

2 Puget Sound Power and Light Company—Schedule 30.

3 BPA E-5 power rate (3 mill/kwh).

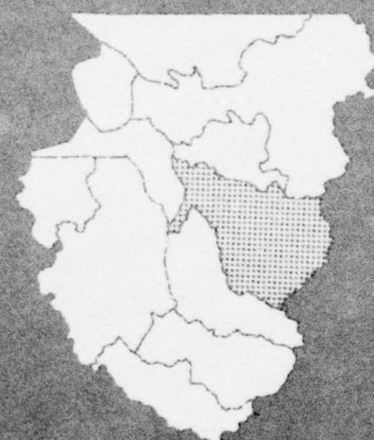
4 Benefits assumed to be at least equal to the cost of the least expensive alternate.

focused on the economies which can be realized by constructing nuclear power plants in conjunction with a desalinization plant. The desalinization plant can utilize steam generated by the power plant's nuclear reactor during off-peak hours which otherwise would be wasted in a straight power plant operation and a single organization can care for the operation and maintenance of both plants.

Water costs for desalinization are constantly decreasing with improved technology, but this solution to water supply problems is economically feasible only in a few extreme situations where the nearest potable supply is a considerable distance away. The Key West Desalting Plant (2.62 million gallons per day) was completed recently and is the only installation in the United States which approaches in size the plant which would be required in Island County. The Key West Plant utilizes the multiple-stage flash evaporation process to deliver desalted water at approximately 85 cents per 1,000 gallons, with fuel oil as the source of energy. The U.S. Atomic Energy Commission predicts costs as low as 19 cents per 1,000 gallons for the integrated nuclear power desalting plants by 1980, but costs of this order would be realized only in extremely large plants producing 500 mgd to 800 mgd gallons per day. (Whidbey and Camano Islands' year 2020 peak day requirements are for 30.2 mgd). This cost is still considerably greater than the approximately 11 cents per 1,000 gallons for water purchased from the city of Anacortes or Everett system for the supply discussed in Alternative 6-A. The supply pipeline conveyance costs for the Island leading from the desalinization plants are not included in the above stated costs.

Summary—An economical desalinization breakthrough is not expected to occur within the next few years. If such a breakthrough does become available, then this Alternative should be re-evaluated. Consequently, Alternative 6-A is selected for the Whidbey-Camano Islands.

Snohomish Basin



SNOHOMISH BASIN

DESCRIPTION OF BASIN

GENERAL

The Snohomish Basin, third largest in the Puget Sound Area, comprises an area of 1,865 square miles of land, 35 square miles of fresh water, and 78 square miles of salt water, and extends about 45 miles in a north-south direction and about 50 miles from east to west. The Basin, including its sub-basins, occupies approximately the southern two-thirds of Snohomish County and the northern half of King County. The major drainage is by way of the Snohomish River, which enters Puget Sound through Port Gardner and Possession Sound in the vicinity of the city of Everett. Two major river systems, the Skykomish and Snoqualmie Rivers, unite to form the Snohomish River. The Skykomish is the largest tributary draining 844 square miles, while the Snoqualmie River drains 693 square miles.

Of the eleven basins in the Puget Sound Area, the Snohomish ranks second in runoff, with an average of 7,100,000 acre-feet of water draining into Puget Sound annually. Ground water in the lowlands is estimated to receive an average of 80,000 acre-feet of recharge annually.

The orographic lifting of the moist maritime air on the windward slopes of the foothills and higher elevations of the Cascades results in an increase in annual precipitation from 35 inches near the Sound to 125 inches or more on the wettest slopes. Approximately 50 percent of the annual precipitation falls in the four months from October through January and 75 percent from October through March. As the more intense weather systems move inland, 3 to 5 inches of precipitation in 24 hours is not unusual on the foothills and higher slopes. Winter snowfall ranges from less than 20 inches near the Sound to 400 inches or more at the crest of the Cascades with a heavy snowpack in the higher elevations.

Streamflow characteristics and other data relating to the hydrology of the Basin are discussed in detail in Appendix III, Hydrology and Natural Environment. The physiographic characteristics of the Snohomish Basin are described in Appendix V, Water-Related Land Resources.

PRESENT SITUATION

Local Economy

Approximately 200,000 people reside in the Snohomish Basin. The cities of Everett and Edmonds account for about 35 percent of the population. Everett is the largest city, with a 1967 population of 52,000. Expansion of the aerospace industry has been an important factor in recent population growth. Another 20 percent of the population lives in the rural inland communities. The balance of the population is rural nonfarm (40 percent) clustered around Everett and Edmonds, and rural-farm (5 percent). Table 7-1 gives historical population statistics for the Basin and principal cities and towns.

TABLE 7-1. Historical population, Snohomish Basin

	1940	1950	1960	1967
Snohomish Basin	83,800	107,200	162,200	201,300
Principal cities and towns:				
Everett	30,224	33,849	40,304	52,000
Edmonds		2,057	8,016	21,800
Snohomish	2,794	3,094	3,894	4,700
Marysville		2,259		4,000
Monroe	1,590	1,556	1,901	2,200
Snoqualmie	775	806	1,216	1,200
North Bend	646	787	945	1,200
Lake Stevens				1,100

Source: Appendix IV, Economic Environment, Appendix V, Water-Related Land Resources.

In the last 100 years, the Snohomish Basin has grown from a few pioneer clearings to an area important in forest products and agriculture. Forest products, lumber, wood products, pulp, and paper

continue to be important mainstays of the economy. The wood and paper products industries are responsible for about 30 percent of the work force.

The Snohomish Basin is an important food supplier for Puget Sound Area residents, producing dairy products, forage crops, vegetables, berries, and poultry products. Numerous frozen food companies, canners, and packing plants provide ready markets for these farm products.

The proximity to deep salt water is important with Everett Harbor serving bulk and general cargo vessels. The inner portion of the harbor accommodates barge tows, log rafting, and pleasure craft.

Land Use

Within the Basin there is a total of 1,194,500 acres of land. The present use of this land is tabulated in Table 7-2 and shown on Figure 7-1.

TABLE 7-2. Present land use, Snohomish Basin

Land Use	Acres	Percent
Forest[1]	1,054,700	88.2
Range	2,400	0.2
Cropland	71,800	6.0
Rural nonfarm	29,300	2.5
Intensive	36,300	3.1
Total	1,194,500	100.0

[1] Includes alpine and other nonforested lands normally associated with forest.

Source: Appendix V, Water-Related Land Resources.

Forests are the largest use of the land, with 88 percent of the lands in this category. Croplands which account for 6 percent of current land use are primarily in the western part of the Basin. Approximately 84 percent of this land is devoted to the production of forage (hay, silage, and pasture) to support a dairy industry.

Intensive land use amounts to 3 percent of total land use. This category consists of residential, commercial, industrial, public and semi-public uses and reserved open space. Intensive land use is tabulated by acres in Appendix V, Water-Related Land Resources as follows: railroads 2,200; roadways 8,600; airports 1,800; urban (built-up) 23,600; for a total of about 36,000 acres.

The major areas of intensive development are along the Puget Sound shoreline from Edmonds through Everett to Marysville and east of Everett. Rural and urban communities include Snohomish, located on the right bank of the Snohomish River; Monroe, Sultan, Skykomish, Gold Bar and Index in the Skykomish drainage; and Snoqualmie, North Bend, Carnation, Duvall and Fall City in the Snoqualmie drainage. A residential community surrounds Lake Stevens.

Land ownership including fresh water areas is shown in Table 7-3.

TABLE 7-3. Land ownership, Snohomish Basin

Ownership	Percent
Private	26.7
Private corporate	21.6
Federal	35.4
State	11.7
Local government	4.6
Total	100.0

Source: Appendix V, Water-Related Land Resources.

PROJECTED ECONOMY AND LAND USE

Local Economy

Since 1950, the Basin has experienced rapid population growth. Recently this growth has been accelerated with the development of an aircraft manufacturing plant at Paine Field by the Boeing Company in 1968.

The Snohomish Basin is expected to continue as an important food supplier. Forest products are also anticipated to be a mainstay of the local economy.

Tabulated in Table 7-4 is a forecast of population, employment, and gross regional product for the Central Division (Snohomish, King, Pierce and Kitsap Counties) and projected population for the Snohomish Basin with these forecasts translated into average annual growth trends.

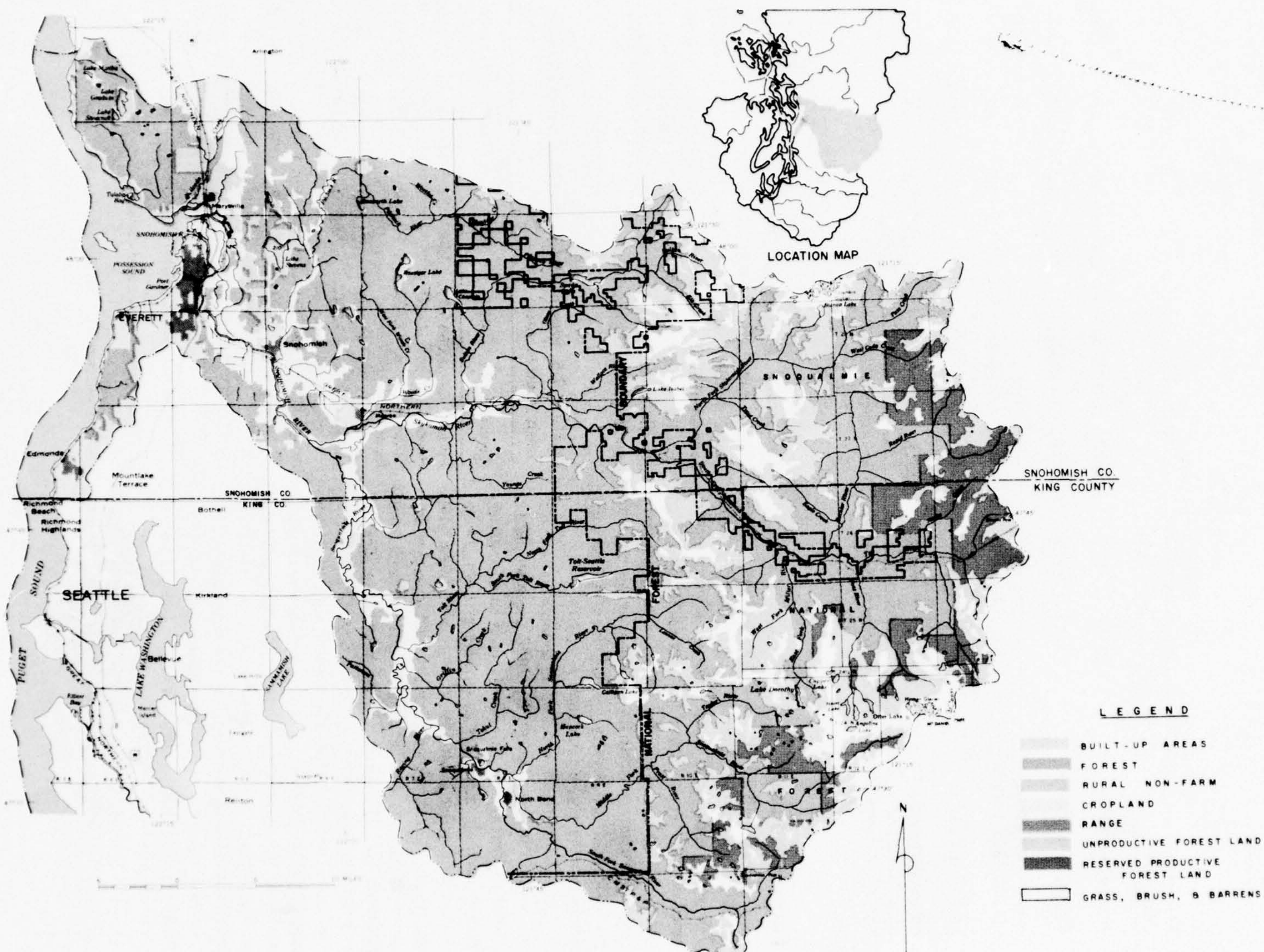


FIGURE 7-1.

SNOHOMISH BASIN
GENERALIZED LAND USE MAP

TABLE 7-4. Economic projections, Snohomish Basin

	1963	1980	2000	2020	Average Annual Growth Trends (Percent) 1963 to 1980	1980 to 2000	2000 to 2020	1963 to 2020
Central Division								
Population (1000's)	1,603.0	2,418.9	3,882.1	6,235.5	2.4	2.4	2.4	2.4
Employment (1000's)	579.1	873.2	1,399.8	2,248.4	2.4	2.4	2.4	2.4
Gross Regional Product (1,000,000's, 1963 $)	5,172.0	10,022.0	24,569.0	62,061.0	3.9	4.6	4.7	4.4
Snohomish Basin								
Population (1000's)	178.2	297.8	467.8	761.4	3.1	2.4	2.4	2.4

Source: Appendix IV, Economic Environment; Appendix V, Water-Related Land Resources.

Future Land Use

The projected land use of the Snohomish Basin for 2020, shown on Figure 7-2, is compared in Table 7-5 with 1967 land use. This land use pattern, based on the construction of a cross-Sound bridge and a bridge between the mainland and southern Whidbey Island, projects for the Snohomish Basin an intensive land use density increase from 4.9 persons per acre to 9.1 persons per acre by 2020.

To support an increase in population of 3.8 times the 1967 population by 2020 there would be a need to increase the intensively used land by about 48,000 acres or 2.3 times its present amount. These lands would come primarily from present forest and agricultural lands. Forest lands would decrease by about 2 percent, cropland by 11 percent and rural nonfarm by 65 percent. The expanding Seattle metropolitan area would push northward and fill in the open spaces along the north-south highway transportation corridor. Some development within the flood plain is expected but early implementation of flood plain zoning would provide a means of restricting mass development of the flood plain. The area east and west of Monroe also would become an extension of Seattle expanding to the terraces above the flood plain.

The area of North Bend would be attractive to light industrial development and for a continuation of residential expansion. Other small communities within the Basin are expected to grow at a moderate rate. Implementation of flood plain zoning would ensure that development of the flood plain is compatible with the flood risks, aid in the retention of fertile lands for agricultural use and provide necessary open space and greenbelts.

TABLE 7-5. Present and projected[1] land use, Snohomish Basin (acres)[2]

Land Use	1967	1980	2000	2020
Forest	1,054,700	1,046,200	1,040,200	1,033,900
Range	2,400	2,400	2,400	2,400
Cropland	71,800	69,900	66,900	63,800
Rural nonfarm	29,300	21,000	13,000	10,400
Intensive	36,300	55,000	72,000	84,000
Total	1,194,500	1,194,500	1,194,500	1,194,500
Population	201,300	297,800	467,800	761,400
Density[3]	4.9	5.5	6.5	9.1

[1] Alternative Land Use Pattern C_2, see Puget Sound Area.

[2] Figures rounded to nearest hundred.

[3] Persons per intensive land use acre.

Source: Appendix V, Water-Related Land Resources.

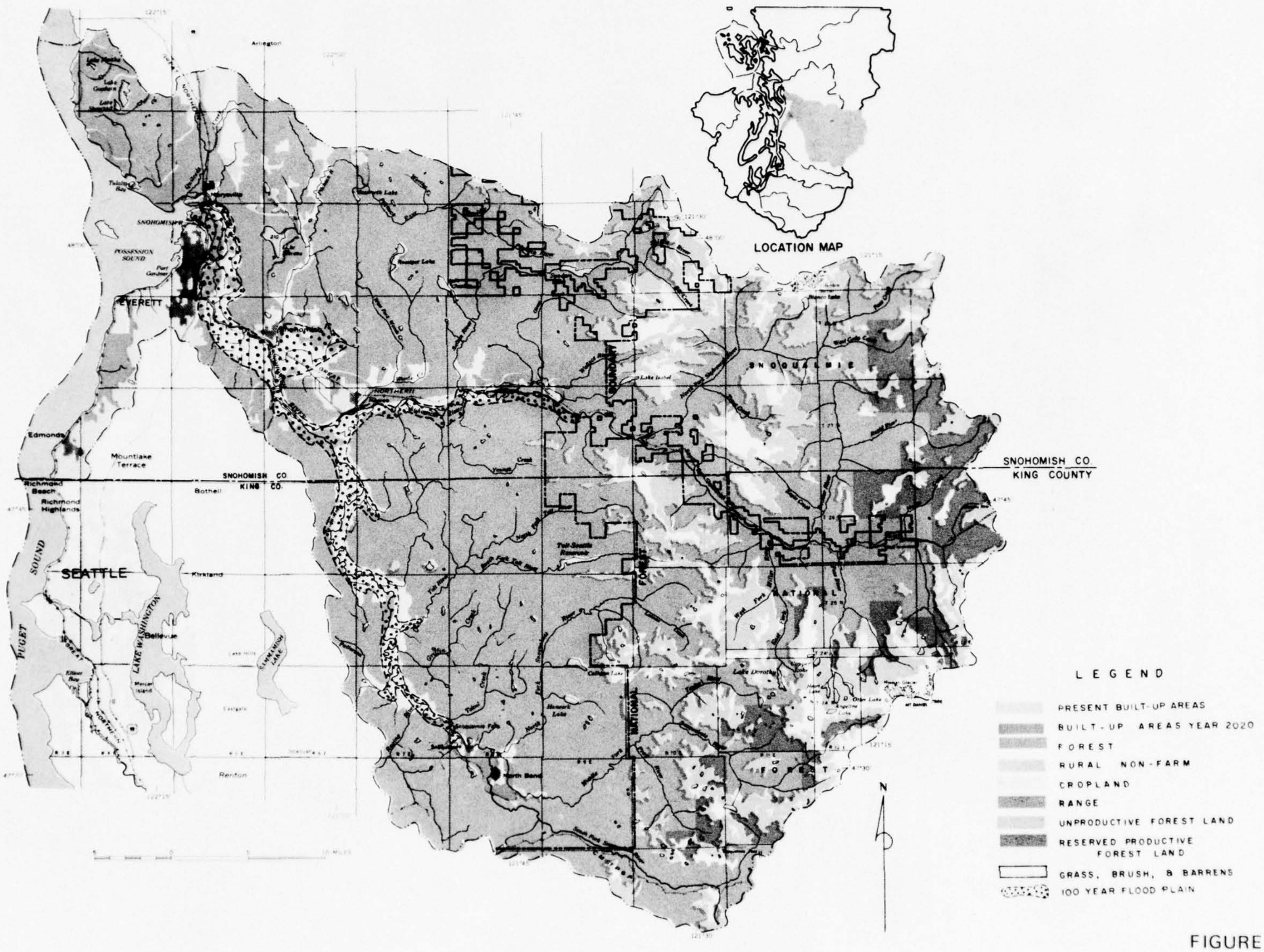


FIGURE 7-2.

SNOHOMISH BASIN
GENERALIZED LAND USE MAP
Alternative C2 –2020

WATER AND RELATED LAND RESOURCE NEEDS

MUNICIPAL AND INDUSTRIAL WATER SUPPLY

General

Surface water is the major source of municipal and industrial water supply in the Snohomish River Basin. Ground water is the sole source of a number of small municipalities.

Everett, the largest single water purveyor, obtains its supply from the Sultan River. Water is diverted from the Sultan River to Lake Chaplain and is then delivered to Everett. In addition to providing for its own needs, Everett supplies water to Monroe, the Alderwood Water District and the town of Snohomish.

Twenty-five percent of the water for the town of Snohomish is supplied from the city of Everett and the remainder from the Pilchuck River. Marysville, Snoqualmie, Carnation, and Skykomish derive their water from springs or wells. North Bend, Gold Bar Water District and Index obtain water supplies from surface sources with Duvall relying upon the Seattle water system. Seattle, located in the Cedar-Green Basins, fulfills a portion of its system needs by interbasin diversion of water from the South Fork of the Tolt River.

Industry uses about 81 percent (139 mgd) of all water consumed in the Basin. All major industrial water users are supplied by municipal sources, with the exception of the Weyerhaeuser Company pulp mill in Everett. This mill presently obtains 32 mgd of water from the Snohomish River.

Present water use is shown in Table 7-6.

Present and Future Needs

Projected growth in population and industrial development within the Snohomish Basin would correspondingly increase municipal and industrial water needs from the 1965 level of about 164 mgd to 540 mgd in 2020. Table 7-7 shows present and projected water needs by major use.

TABLE 7-6. Municipal and industrial water use, 1965, Snohomish Basin

System	Estimated Population Served	Surface Water Usage (mgd) Average Daily	Surface Water Usage (mgd) Maximum Monthly	Surface Water Usage (mgd) Maximum Daily	Ground Water Usage (mgd) Average Daily	Ground Water Usage (mgd) Maximum Monthly	Ground Water Usage (mgd) Maximum Daily
MUNICIPAL USE							
Everett	135,000	21.60	26.10	38.00	--	--	--
Alderwood District	(66,000)	(5.60)	(8.50)	(14.00)	--	--	--
Marysville	(4,500)	(0.75)	1.12)	(1.50)	--	--	--
Monroe	(4,500)	(0.35)	(0.40)	(0.55)	--	--	--
Snohomish	(4,000)	(1.50)	(3.00)	(4.25)	--	--	--
Edmonds[1]	10,000	0.58	0.87	1.16	--	--	--
Snoqualmie	2,700	--	--	--	0.16	0.31	0.47
North Bend	2,000	0.20	0.22	0.25	--	--	--
Carnation	1,250	--	--	--	0.12	0.25	0.36
Fall City Water Company	1,200	--	--	--	0.10	0.20	0.29
Duvall[2]	(525)	(0.03)	(0.06)	(0.10)	--	--	--
Skykomish Water District	500	--	--	--	0.10	0.20	0.30
Other rural community systems	2,110	0.28	0.39	0.44	0.10	0.21	0.35
Subtotal	154,760	22.69	27.58	39.95	0.58	1.17	1.77
RURAL-INDIVIDUAL USE	35,940	0.20[3]	0.28	0.40	1.78	2.50	3.50
INDUSTRIAL USE							
Municipally supplied:							
Everett							
Paper and allied		102.00	106.00	112.00	--	--	--
Lumber and wood		2.15	2.35	2.63	--	--	--
Chemicals, metals, oils		0.05	0.07	0.08	--	--	--
Stone, clay, glass		0.25	0.25	0.30	--	--	--
Snohomish							
Food and kindred		1.75	1.90	2.10	--	--	--
Self supplied:							
Paper and allied		32.00	33.30	35.20	--	--	--
Stone, clay, glass		0.12	0.12	0.12	0.36	0.72	1.08
Subtotal		138.30	144.00	152.40	0.36	0.72	1.08
Total	190.700	161.21	172.00	193.00	2.72	4.40	6.40

1 Edmonds also supplied by Alderwood Water District and Olympic View Water District.

2 Duvall served by Seattle.

Source: Appendix VI, Municipal and Industrial Water Supply.

TABLE 7-7. Projected municipal and industrial water needs, Snohomish Basin

Year	Use	Total (Average Daily M.G.D.)	Total (1000 Acre-Feet Annually)	Net Needs[1] (M.G.D.)	Net Needs[1] (1000 Acre-Feet)
1965	Municipal	23.3	26.1		
	Industrial	138.7	155.5		
	Rural-Individual	2.0	2.2		
	Total	164.0	183.8		
1980	Municipal	48.9	54.9		
	Industrial	214.0	239.5		
	Rural-Individual	3.2	3.4		
	Total	266.1	297.8	102.1	114.0
2000	Municipal	91.7	103.0		
	Industrial	323.2	362.0		
	Rural-Individual	4.4	4.5		
	Total	419.3	469.5	255.3	285.7
2020	Municipal	170.5	191.5		
	Industrial	365.1	408.5		
	Rural-Individual	4.3	4.5		
	Total	539.9	604.5	375.9	420.7

[1] Cumulative total above 1965 use.

Source: Appendix VI, Municipal and Industrial Water Supply.

IRRIGATION

General

The Basin contains about 43,100 acres of potentially irrigable lands of which 12,800 acres now are irrigated. The irrigated lands are located on upland terraces north of Marysville and on alluvial flood plains of the Snoqualmie, Skykomish, Pilchuck, and Snohomish Rivers. About 3,200 acres of the potentially irrigable lands are covered with trees.

Water supply for the irrigated lands primarily is received from surface diversions with only 25 percent of supply obtained from ground water. The Skykomish, Snoqualmie and Snohomish Rivers and tributaries provide the major portion of surface supply.

Present and Future Needs

An additional 7,200 acres of lands are expected to be under irrigation by the year 2020. Peak surface water diversions are forecast to reach 147 cfs by 1980; 191 cfs by 2000; and 211 cfs by 2020. Future irrigation water net needs are as shown in Table 7-8.

TABLE 7-8. Irrigation present status and projected needs, Snohomish Basin

Year	New Irrigation (acres)	Total Irrigation (acres)	Total Annual Diversion (ac. ft.)	Net Needs[2] (ac. ft.)
1966		12,800	24,500	--
1980	6,100	14,800[1]	28,200	11,700
2000	3,900	18,700	35,700	19,200
2020	1,300	20,000	38,200	21,700

[1] Approximately 4,100 acres of irrigated land are expected to be taken out of production at Marysville.

[2] Cumulative annual diversion above 1966 use.

Source: Appendix VII, Irrigation.

The monthly distribution of the irrigation requirements are shown below as percent of annual demand:

May	7%	July	34%	September	12%
June	19%	August	28%	Total	100%

WATER QUALITY CONTROL

General

The waters of the Snohomish Basin are low in dissolved solids with the average for all streams measured being about 25 ppm. Ground waters usually have concentrations of less than 20 mg/l. Dissolved oxygen concentrations throughout the Snohomish River system are normally near saturation levels. Recorded stream temperatures reveal minimum temperatures from 32°F to 34°F and maximum temperatures from 67°F to 74°F.

The chemical characteristics are quite similar for all the major tributaries. The Skykomish and Snoqualmie Rivers differ slightly from the Sultan and Tolt Rivers by having lower magnesium concentrations than the latter. Ground water in the Basin contains concentrations of iron as high as 9 mg/l, especially where peaty or boggy soils are present.

The Snohomish River can be very turbid during flood stages with turbidity readings up to 1,000 JTU having been recorded. Over 360,000 tons of silt are estimated to be transported down the river annually.

Port Gardner Bay receives both partially treated and untreated industrial wastes. The major portion of these are contributed from the sizeable pulp and paper industry. Municipal waste effluent from Everett's lagoon also is received in the bay. The raw municipal and industrial wasteload generated in the Snohomish Basin approximates over 7,000,000 PE of which only 5 percent is removed presently by treatment before being discharged to fresh and marine waters. The waters receiving the largest quantity of waste are Everett Harbor and Port Gardner. The Snohomish River receives the next largest quantity of wastes, but it is less than 2 percent of the Basin's total. Bacteriological quality data for the Snohomish area indicate a general trend of increasing coliform concentrations from the headwaters to the mouth. 1965 waste generation, treatment and discharges are summarized in Table 7-9.

TABLE 7-9. Summary of municipal and industrial wastes, Snohomish Basin ,1965

Receiving Water	Estimated Population Served	Nonseasonal Untreated Waste PE	Seasonal Untreated Waste PE	Treatment	Nonseasonal Waste Discharge PE	Seasonal Waste Discharge PE
Skykomish River						
Sultan	500	500	--	Primary	500	--
Monroe	1,950	2,400	--	Primary	1,700	--
Food processing	--	--	2,400	Monroe	--	2,000
Transportation equipment	--	15,000	--	Neutral.	15,000	--
State Reformatory	1,000	1,000	--	Lagoon	400	--
Snoqualmie River						
North Bend	900	1,200	--	Primary	840	--
Snoqualmie	1,200	1,500	--	Lagoon	220	--
Snoqualmie Falls	300	400	--	Primary	250	--
Pilchuck River						
Granite Falls	600	700	--	Primary	450	--
Lake Stevens						
Food processing	--	--	2,500	None	--	2,500
Snohomish River						
Snohomish	4,000	8,400	--	Lagoon	5,000	--
Food processing	--	--	42,000	City	--	33,000
Food processing	--	--	1,250	None	--	1,250
Food processing	--	700	--	Primary	300	--
Paper and allied	--	75,000	--	Primary	60,000	--
Lumber and wood	--	700	--	None	700	--
Ebey Slough						
Marysville	3,000	4,000	--	Lagoon	1,100	--
Food processing	--	--	8,000	City	--	2,000
Tanning	--	--	600	Lagoon	--	350
Possession Sound						
Everett	41,000	45,000	--	Lagoon	2,000	--
Food processing	--	4,000	1,100	None	4,000	1,100
Lumber and wood	--	11,600	--	None	11,600	--
Paper and allied	--	6,391,000	--	None	6,391,000	--
Paper and allied	--	500,000	--	Lagoon	238,000	--
Mukilteo	1,300	1,500	--	Primary	1,000	--
Paine A.F.B.	1,000	1,300	--	Secondary	200	--
Lynwood	10,200	12,000	--	Primary	9,000	--
Edmonds	10,000	31,000	--	Primary	19,000	--
Mountlake Terrace	12,000	(14,000)	--	Edmonds	(8,000)	--
TOTAL	88,950	7,109,000	57,850	--	6,762,200	42,200
Municipal	--	111,000	--	--	42,000	--
Industrial	--	6,998,000	--	--	6,720,200	--

Source: Appendix XIII, Water Quality Control.

Present and Future Needs

State-Federal water quality standards provide the baseline from which present and future needs for water quality control are determined. The water quality classification established by the State for each watercourse in the Basin are outlined in Appendix XIII, Water Quality Control.

The raw wasteload expected in the Snohomish Basin by 1980 is 5,886,000 PE. Paper and allied products would account for 90 percent of the raw waste produced, while municipalities and food and kindred industries would account for only about 6 percent. Municipal waste production, primarily from the Everett area, is expected to make a three-fold increase from 111,000 PE in 1965 to 322,000 PE in 1980.

The 1965 and projected wasteloads are shown in Table 7-10.

TABLE 7-10. Present and projected raw wasteloadings, Snohomish Basin (1000's PE)

Year	Municipal	Industrial[1]	Recreational	Total	Net Needs[2]
1965	111	7,029	29	7,169	6,182
1980	322	5,513	51	5,886	5,429
2000	547	5,435	97	6,079	5,722
2020	927	4,953	177	6,057[1]	5,700[1]

[1] Decrease in raw wastes due to change in pulp and paper process.

[2] Cumulative raw wasteload requiring treatment above that receiving treatment in 1965.

Source: Appendix XIII, Water Quality Control.

NAVIGATION

General

Everett Harbor is the principal harbor development in the Snohomish Basin. The harbor accommodates craft transporting general cargo, forest products, petroleum, dry bulk and liquid bulk in foreign import and export as well as coastwise transport of these products.

Navigation in the Snohomish River is confined almost entirely to the lower 8-mile estuarine zone of the river. The bulk of river traffic consists of movements of logs, poles and piling, and shipments of wood products.

A minor harbor for small boats is located at Tulalip on Tulalip Bay, about 4 miles northwest of Everett. Another minor harbor is located at Norma Beach on the east side of Possession Sound. A military reservation with a tank farm and pier for handling bulk petroleum is located at Mukilteo, in addition to a ferry landing and facilities for small boats.

Seven small boat harbor facilities supply about 860 wet moorages.

Present and Future Needs

The major problem in maintaining Everett Harbor is the bedload of sand and silt carried by the Snohomish River. The average annual dredging required to maintain the authorized navigation channel on the lower Snohomish is about 250,000 cubic yards.

Projected tonnages of waterborne commerce for the Snohomish Basin are shown in Table 7-11 which also shows projected small boat wet moorage needs. Forest products and other dry bulk are expected to account for the major tonnage through 1980.

TABLE 7-11. Projected pleasure boating needs and waterborne commerce, Snohomish Basin

	Small Boat Wet Moorages			Waterborne Commerce (1000's Short Tons)	
Year	Total	Net Needs[1]	Year	Total	Net Needs[2]
1966	3,020	2,156	1963	2,700	--
1980	4,920	4,056	1980	3,800	1,100
2000	9,530	8,666	2000	10,900	8,200
2020	18,520	17,656	2020	50,000	47,300

[1] Cumulative needs above the 864 wet moorages available in 1966.

[2] Cumulative waterborne commerce above total for 1963.

Source: Appendix VIII, Navigation.

Additional terminal and water transport-oriented industrial lands would be required to accommodate the projected commerce for the Basin. Additional dredging of channels would be required to

obtain sufficient depths for the vessels expected to be serving the port in the future. Table 7-12 summarizes future harbor and channel requirements, and terminal and industrial land needs.

TABLE 7-12. Harbor and channel and terminal and water transport-oriented industrial land requirements, Snohomish Basin

Year	Harbor and Channel Req. (vessel draft in feet)			Terminal and Industrial Land (acres)	
	Freighters	Bulk Carriers	Tankers	Total	Net Needs[1]
1963	--	--	--	700	--
1980	39	40	45	1,600	900
2000	40	71	47	5,600	4,900
2020	40	71	48	12,300	11,600

[1] Cumulative needs above 1963 land use.

Source: Appendix VIII, Navigation.

POWER

General

The only hydroelectric project in the Snohomish Basin consists of Snoqualmie Falls No. 1 and No. 2 on the Snoqualmie River, owned by Puget Sound Power and Light Company, and has a total installed capacity of 41,700 kw. Lands occupied by BPA transmission and substation facilities in the Basin total approximately 3,950 acres. The Snohomish County Public Utility District No. 1 has previously proposed installation of 140,000 kw power facilities on the Sultan River. The Federal Power Commission (FPC) license application indicates: 84,000 kw at the existing Sultan River Dam (Powerhouse No. 1); 32,000 kw in Powerhouse No. 2; and 24,000 kw in Powerhouse No. 3, wherein these powerhouses are part of a plan for future downstream run-of-river dams. No hydroelectric power has been installed on the Sultan River to date.

A potential for installation of 60,000 kw of hydropower exists on the North Fork of the Snoqualmie River as part of a multiple-purpose storage project. The city of Snohomish has been granted an FPC permit to investigate the possibility of building a multiple-purpose dam for water supply and 4,000 kw of installed hydroelectric capacity on the Pilchuck River.

Present and Future Needs

The Basin's electrical energy needs are expected to grow even faster than the rate of population expansion. Additional power generation and transmission facilities would be necessary to meet these needs. There are a number of sites in the Basin having a potential for hydroelectric power development. These include pumped-storage sites as well as multiple-purpose storage sites where power could be provided as an additional project purpose.

A number of thermal-nuclear power plants would be required in addition to power supplied from the Pacific Northwest regional system to meet the future needs of Puget Sound Area. The possibility of a nuclear-fired power plant being located in the Snohomish Basin is unknown at this time. Further location, economic and environmental impact studies must be conducted before specific sites can be selected. Power needs are discussed further in the Area portion of this Appendix.

FLOOD CONTROL

General

The 59,000-acre flood plain of the Snohomish, Snoqualmie, and Skykomish Rivers is subject to frequent flooding. Lands in the flood plain are utilized almost entirely for agriculture and contain farm buildings and residences, as well as portions of the towns of Carnation, Snoqualmie, North Bend, Monroe, Sultan, Gold Bar, Index, and several industrial enterprises located near Everett and Lowell. Flood damages begin when flows begin to exceed about 22,600, 40,000 and 43,000 cfs at Snoqualmie, Gold Bar, and Snohomish, respectively.

The Snohomish River Basin characteristically has two high water periods. One occurs in the late fall, coinciding with maximum precipitation, and the other coincides with spring snow melting in high areas. Table 7-13 lists the peak discharges and recurrence intervals of recent major floods and 50 and 100-year floods at Snohomish. Estimated flood damages are based on 1966 prices and conditions.

TABLE 7-13. Major floods and estimated damages, Snohomish Basin

	Peak Discharge of Snohomish R. at Snohomish (cfs)	Average Recurrence Interval (years)	Current Estimated Damages
10 Feb. 1951	136,000	87	$ 7,980,000
23 Nov. 1959	113,300	28	6,730,000
Estimated	124,000	50	10,760,000
Estimated	139,000	100	16,980,000

Source: Appendix XII, Flood Control.

Existing flood control measures include flood forecasting and warning service by the U.S. Weather Bureau; flood protective works consisting of levees along the Snohomish, Snoqualmie and Skykomish Rivers and tributaries and flood plain management. Public Law 566 Water Management Projects includes the French Creek and Marshland Flood Control Districts.

The levees provide protection from normal spring floods which would otherwise severely damage crops but do not prevent flooding by large spring or winter floods, particularly during periods of high tides. Overtopping of the levees along the Snohomish River may be expected at intervals of 2 to 5 years, depending on the height and conditions of the levees. Unprotected areas along the Snohomish, Snoqualmie and Skykomish Rivers are flooded annually in lower areas and less frequently in higher areas. There are no flood control storage reservoirs to regulate flows, and the river discharges at Snohomish fluctuate widely from a maximum of about 136,000 cfs in the flood season to less than 1,500 cfs in the late summer.

The steep gradient of the principal tributaries results in high discharge velocities which constantly erode the riverbanks. Debris and bedload are deposited in the lower river reaches where the stream gradient flattens. This diverts the stream channel causing further erosion or flooding.

Present and Future Needs

The present average annual flood damages of $2,310,000 occur to croplands, buildings, transportation facilities and flood protective works. The trend of development within the Basin is expected to result in the future growth of flood damages approximately 3.75 percent compounded annually if additional flood control is not provided. Future growth of average annual flood damages are expected to be $3,520,000 in 1980; $6,370,000 in 2000; and $13,100,000 in 2020 (see Table 7-14).

Flood control is required to reduce current levels of flood damages and to allow more intensive agricultural utilization of flood plain lands. Industrial demands for a minimum of 2,000 acres in the Snohomish River delta area would require at least a 100-year level of flood protection. Existing and future urban developments near Everett, Snohomish, Carnation, Snoqualmie, North Bend, Monroe, Sultan, Gold Bar, Index and Skykomish should be provided a 100-year level of flood protection. The entire flood plain should be managed to insure that land use is compatible with the degree of flood protection provided and to enable retention of fertile farm lands for agrarian open space and greenbelts.

TABLE 7-14. Projected flood damage reduction needs,[1] Snohomish Basin

Year	Total ($1000)	Net Needs[2] ($1000)
1966	2,310	2,310
1980	3,520	3,520
2000	6,370	6,370
2020	13,100	13,100

[1] Based on 1966 prices and conditions.

[2] Damages which will occur without additional measures.

Source: Appendix XII, Flood Control.

WATERSHED MANAGEMENT

General

Watershed management is primarily concerned with treatment measures for reduction of floodwater damage, protection and rehabilitation of watershed lands, and water management. Implementation of one measure may be less effective without application of one or more other measures to the same area.

Present and Future Needs

The needs for watershed management are complex, and two or more practices and measures may be required on the same area of land. Many measures and treatments become involved in integrated programs and projects. The watershed management needs for the Basin are tabulated in Table 7-15.

While the area needing treatment remains nearly the same, the nature and intensity of treatment varies with land capability and changes in use.

The broad needs for improved technology programs and projects are given under the Area portion of this Appendix.

TABLE 7-15. Total watershed management needs, Snohomish Basin

Year	Flood Prevention[1] (acres)	Watershed Protection and Rehabilitation (acres)	Water Management Agricultural (acres)	Water Management Urban (acres)
1980	65,600	1,194,600	25,700	65,700
2000	65,600	1,194,600	42,900	81,000
2020	65,600	1,194,600	57,200	130,100

[1] Includes flooding on main streams but not forested land within flood plain areas.

Source: Appendix XIV, Watershed Management.

RECREATION

General

Water-based recreation resources within the Snohomish Basin include about 50 miles of Puget Sound shoreline, a number of lakes, rivers, and small streams. Better known large fresh water areas include Sultan Reservoir, Lake Stevens and the Snohomish, Snoqualmie, and Skykomish Rivers. The eastern half of the Basin contains many attractive, small high-elevation lakes. A group of such lakes is included within a proposed Alpine Lakes Wilderness Area in the Snoqualmie National Forest. Access to many of the lakes is difficult with surrounding lands often entirely in private ownership. Other recreational attractions include the mountainous areas of the Cascade Range which contains about 104,000 acres of alpine and subalpine terrain and a large section of the Glacier Peak Wilderness. There are extensive winter sports developments at Stevens and Snoqualmie Passes.

The Basin is less than a one hour drive from the Seattle metropolitan area which has a population of about 1,000,000. This exposes much of the Basin to heavy recreation use.

In 1964, the Basin contained 112 publicly-administered outdoor recreation areas. The Forest Service administered 25 areas; the State, 55; county, 9; and the cities, 24. Of the 557,351 acres of land available for public visitation, 419,809 acres are within National Forests. The Forest Service reported visitation in 1964 to the Mount Baker and Snoqualmie National Forest amounted to about 3,500 and 556,400 visits, respectively.

Approximately 155 miles of rivers are suitable for boating including the Snohomish (18 miles), the Snoqualmie (35 miles), North Fork of the Snoqualmie (12 miles), Middle Fork of the Snoqualmie (16 miles), South Fork of the Snoqualmie (8 miles), and Tolt (4 miles), the Pilchuck (18 miles), the Skykomish (40 miles), and the Beckler River (4 miles).

Present and Future Needs

The present and future demand for water-related recreation expressed in recreation days is as shown in Table 7-16.

TABLE 7-16. Present and projected water-related recreation demand, Snohomish Basin (1000's recreation days)

Year	Total	Net Needs[1]
1960	3,600	1,600
1980	7,200	5,200
2000	14,000	12,000
2020	26,000	24,000

[1] Cumulative needs above 2,000,000 recreation days satisfied by facilities existing in 1960.

Source: Appendix X, Recreation.

The 1960 supply of developed lands was inadequate to satisfy boating, camping and picnicking demands of that year. In addition to lands developed for boating facilities, an additional 2,741 rental moorage spaces were needed in 1966 to satisfy boating demands. There are enough natural waters to satisfy water-based recreation demands until 1975.

In addition to indicated needs, urban parks, scenic routes, waterfront access, recreation rivers, special interest areas, interpretive facilities, open spaces, and beaches and trails for activities other than swimming and hiking are necessary to satisfy the recreation and environmental needs of the people.

FISH AND WILDLIFE

General

The Snohomish River with its principal forks, the Skykomish and Snoqualmie Rivers, offers nearly 85 miles of accessible main-stem river for the spawning and rearing of anadromous fish. In addition there are more than 270 miles of tributary streams available to the anadromous species. The fish production from the Snohomish Basin ranks very high in the Puget Sound Area commercial and sport fisheries. Resident game fish populations are important above both man-made and natural anadromous fish barriers. All stream areas below larger impassable obstructions are completely utilized by salmon, steelhead, whitefish, and other fish species. Fish production in the Snohomish River system is significantly limited by urban, industrial and agricultural development of the area. Streambeds offer some of the best spawning and rearing areas within the Puget Sound Area.

Resident wildlife species inhabit the entire Snohomish Basin. Some conflicts exist between hunter use and land owner restrictions. Altering of the habitat has had a profound affect on big game, fur bearing animals and waterfowl.

Present and Future Needs

There is a need to retain and expand fishing opportunities for trout, steelhead, salmon and other species in the Snohomish Basin. Similarly, there is a need to provide opportunities for hunting commensurate with the growth in population. The projected fishing and hunting needs are shown in Table 7-17.

TABLE 7-17. Fish and wildlife, sport and commercial needs, Snohomish Basin

		1965	1980		2000		2020	
	Unit	Total	Total	Net[1]	Total	Net[1]	Total	Net[1]
Sport Fishing								
Salmon	1000 User-Days	41	68	27	125	84	211	170
Game Fish	1000 User-Days	888	1,483	595	2,332	1,444	3,732	2,844
Marine Fish	1000 User-Days	4	5	1	7	3	10	6
Shellfish	1000 User-Days	3	5	2	6	3	7	4
Total		936	1,561	625	2,470	1,534	3,960	3,024
Hunting	1000 User-Days	99	192	93	311	212	383	284
Commercial Fishing	1000 Pounds			2,551		3,387		6,202

[1] Cumulative need above 1965 activity.

Source: Appendix XI, Fish and Wildlife.

COMPREHENSIVE PLAN

BASIS OF PLANNING

Desires of Local People

During a public hearing held in Everett on 22 October 1964, local interests expressed a desire for: improvements to reduce flood damages; an adequate water supply to serve municipal and industrial needs of Everett; stabilization of eroding riverbanks; development of recreation facilities; augmentation of low water flows for fish; development of the Snohomish River delta for navigation and industrial use; preservation and enhancement of existing scenic and recreation areas by maintaining valley lands in greenbelts and open space; and the maintenance of streams in a natural free-flowing state (see Appendix I, Digest of Public Hearings).

Summary of Basin Needs

The needs of the Snohomish Basin projected for 1980, 2000 and 2020 are summarized in Table 7-18.

TABLE 7-18. Summary of needs, Snohomish Basin

Feature	Units	Cumulative Net Needs[1] 1980	2000	2020
M&I Water Supply	mgd	102.1	255.3	375.9
	(1000 Acre-Feet)	(114.0)	(285.7)	(420.7)
Irrigation	1000 Acre-Feet	12	19	22
Water Quality Control				
Waste	1000 Population Equivalents	5,429	5,722	5,700
Flow[2]	cfs	400	750	890
Navigation				
Commercial	1000 Short Tons	1,100	8,200	47,300
Pleasure Boats	Wet Moorages	4,056	8,666	17,656
Power[3]				
Flood Control	$1000 Damage Reduction	3,520	6,370	13,100
Watershed Management				
Flood Prevention	1000 Acres	65.6	65.6	65.6
Watershed Protection and Rehabilitation	1000 Acres	1,194.6	1,194.6	1,194.6
Water Management				
Agricultural	1000 Acres	25.7	42.9	57.2
Urban	1000 Acres	65.7	81.0	130.1
Recreation	1000 User-Days	5,200	12,000	24,000
Fish and Wildlife				
Sport				
Fishing	1000 User-Days	625	1,534	3,024
Hunting	1000 User-Days	93	212	284
Commercial Fishing	1000 Pounds	2,551	3,387	6,202

[1] See Water and Related Land Resource Needs for derivation of net needs.

[2] Snohomish River.

[3] Power needs were projected for the Puget Sound Area only.

General Planning

A wide range of alternative nonstorage and management opportunities were viewed to meet the water supply needs of the Snohomish Basin. These included diversion structures, direct river pumping and treatment, desalinization, interbasin water transfer, further ground water utilization, and improved water yields through various watershed management practices. Levees, channelization, diversion, flood plain management, bank protection, and improved land use management practices were considered as possible means of meeting flood control and watershed management needs. Opportunities considered for satisfaction of water quality needs were sewage collection and treatment facilities and minimum flows available to assimilate residual wasteloadings. The water and related land resource was examined in terms of projected land use pattern C_2, (see Projected Land Use) with the land needs of navigation, power, recreation, open space, greenbelts, and fish and wildlife considered within this context.

There are storage sites on a number of Snohomish Basin rivers which could provide opportunities for water control and to more fully utilize the resource in meeting water supply needs and minimum streamflow requirements for anadromous and resident fish. Over 540,000 acre-feet of aggregate storage could be developed at sites on the North and Middle Forks of the Snoqualmie, North Fork Skykomish, Sultan, Miller, Beckler, Pilchuck and South Fork Tolt Rivers. With storage there would be sufficient quantities of water to meet projected water supply needs even during a year of extreme low runoff without reducing streamflows below minimums critical to fish. For further information on minimum streamflows for fish see the Area discussion on Fish and Wildlife.

Alternative objectives were considered in developing the Comprehensive Plan. The objectives represented both ends of the spectrum of interests, i.e., economic efficiency and environmental quality as discussed in the Puget Sound Area section of this Appendix. The alternative elements considered in plan formulation are described under Alternative Elements .

The single-purpose Appendices, V through XIV, provided a wide array of solutions. Necessary adjustments were made to these solutions in the formulation of a comprehensive plan for the Basin. These adjustments consisted of:

(a) Flood control storage sites, contained in Appendix XII, on the Miller, Beckler, Pilchuck and Skykomish Rivers were not used. Flood plain management and levees were considered to be the better solutions for the long-range period with these rivers left in their free-flowing state.

(b) Municipal and industrial water supply projects contained in Appendix VI were modified with storage on the Pilchuck and Skykomish Rivers eliminated. Storage on the Pilchuck was eliminated to gain economies of scale and minimize adverse impacts on the natural environment with water to be purchased from Everett. Storage on the Skykomish was eliminated due to the availability of more economic alternatives and the need to retain free-flowing streams. Long-range water needs of Everett would be met by direct pumping from the Snohomish River and treatment.

(c) Fish and wildlife measures contained in Appendix XI were modified to a minor extent with additional artificial propagation facilities planned in lieu of several storage projects required for flood control and low flow augmentation. Cross-sectional stream surveys planned for the early action period to determine the minimum and optimum streamflows required for fish production may show that further consideration should be given to storage development.

SUMMARY OF PLAN

Early Action 1970-1980

During this period municipal and industrial water supply needs of the city of Everett and its service area would be satisfied through raising of Culmback Dam on the Sultan River. Ground water resources would continue to supply small and rural communities with industry also continuing to meet a portion of its water requirements by pumping from the Snohomish River or one of its sloughs.

About 6,100 acres of cropland would be placed under irrigation with water supplied by individual farmers from both surface and ground sources. This increase would be offset somewhat by 4,100 acres of land which would be taken out of crop production and put to higher more intensive use.

Compliance with Washington State water quality standards would be obtained through installa-

tion of adequate collection and treatment facilities by a number of communities and cities in the Basin. Pulp mills would remove settleable solids from mill effluents prior to discharge and would install adequate outfalls and diffusers to achieve maximum dilution and dispersion into Puget Sound. A water quality surveillance program would be expanded in order to provide an adequate monitoring system with sampling stations on marine and fresh water. A comprehensive sewerage plan would be developed for the Basin.

Navigation needs would be met through channel deepening projects on the East Waterway and on the Lower Snohomish River, below the Highway 99 Bridge. These channels would be deepened to accommodate bulk carriers and freighters. Lands found to be suitable for terminal or water transport-oriented industrial development would be retained for this purpose to insure future availability. Development of the Snohomish River delta and a dredge fill in Everett Harbor would begin during this period in order to provide a basis for future port expansion. Concurrent with development of the delta open spaces and recreational areas would be set aside to meet environmental needs. Wet moorage would be provided for pleasure boaters through the construction of two small boat harbors with 3,130 moorage slips.

Power needs for the Basin would be satisfied by the Northwest Regional system which is discussed under Power in the Area portion of this Appendix. Power facilities at a multiple-purpose storage project and downstream reregulating dam on the North Fork of the Snoqualmie River would produce a total of 60,000 kilowatts of electric energy. These projects are included in the early action portion of the Plan.

Multiple-purpose storage projects on the North and Middle Forks of the Snoqualmie River would provide significant flood control for the Snoqualmie River flood plain. The projects would provide a 100-year level of flood protection along the Snoqualmie River from North Bend to Snoqualmie Falls, and approximately 25-year protection from Snoqualmie Falls to the confluence of the Skykomish River. Flood control storage provided from second stage construction of Culmback Dam on the Sultan River would enable a 100-year level of flood protection along the lower Sultan River. In the lower Snohomish River significant contributions to flood damage reduction would result from both the Snoqualmie and Sultan River projects. These projects, together with the setting back of levees at French Creek and Marshland drainage districts would reduce the frequency of winter flooding of the districts at a current reoccurrence interval of once every 2 to 4 years to once every 25 years. As the Snohomish River delta is developed the existing natural floodways would be adjusted by enlarging the channel capacity of the Snohomish River and its sloughs as it enters into Possession Sound to insure 100-year level of flood protection for these industrial developments. Flood plain management would provide an effective means of reducing future flood damages through land use zoning of lands in the flood plain consistent with the levels of protection provided and aid in the retention of open spaces and greenbelts. Floodproofing and warning systems would also be implemented. These measures would contribute significantly to the reduction of future flood damages and are relied upon to a large measure in the Skykomish River Basin.

Two small watershed multiple-purpose projects are planned for implementation during this period to achieve floodwater damage reduction and water management. One project is located in the Patterson Creek drainage and the other in the Snohomish estuary. These projects consist of stabilized channels and outlet control structures. Important complements to the watershed management projects are the programs of technical assistance and management and land treatment and drainage.

Campgrounds, picnic areas, beaches, and boat launching ramps would be developed on existing public lands together with the acquisition of additional land and water areas to satisfy recreational needs. Recreation sites would be developed as part of the multiple-purpose storage projects on the North and Middle Forks of the Snoqualmie River. Additional land and water areas would be acquired along the Puget Sound shoreline to provide badly needed marine parks. Over 100 recreation areas would be expanded or developed before 1980.

Land acquisition including access and fish and wildlife enhancement projects would be undertaken to increase the opportunities for this form of outdoor recreation. Additional fish hatcheries would be constructed for both resident and migratory fish together with rearing ponds, spawning channels and fish passage improvements including a collection and

transportation facility to provide migratory fish access above the 268-foot high Snoqualmie Falls. Low flow augmentation would be provided from the North and Middle Fork Snoqualmie multiple-purpose storage projects and from the Sultan River project. Important cross-sectional stream surveys would be undertaken during this period in order to determine the minimum and optimum streamflows required for fish production. Subsequent to these cross-sectional surveys further studies of new projects may be required as well as reconsideration of the operation of existing projects.

Long-Range, 1980-2020

Expansion of the transmission system from Lake Chaplain to the distribution works would be necessary as well as the development of an additional water supply source to satisfy the Everett service area water supply needs through the year 2020. The new source would be the Snohomish River with a pumping and treatment plant located near the river upstream from tidal influences. The plant together with the Sultan system would provide an adequate source of water to meet Everett's needs. The small and rural communities would be supplied from Everett and the Seattle water systems with some further development of surface water in the lower Snohomish River by industry expected up to the year 2000.

An additional 5,200 acres of land would be placed under irrigation during this period with water supplied primarily from the Snoqualmie, Skykomish, Snohomish and Pilchuck Rivers as well as some ground water development in the Snohomish subbasin.

Existing treatment and collection facilities would be expanded commensurate with the growth in population and industrial development to insure that the State water quality standards are continually met. The water quality monitoring, evaluation and control program would be maintained.

Further development of the Snohomish Delta is envisioned during this period as terminal and water transport-oriented industrial sites would be required to meet the navigation needs of the Basin. A continuous dredge operation would be undertaken to develop new lands through dredge fill as the ship channels are maintained. Continuous dredging would be required in order to maintain these channels as the silt load of the Snohomish River is extremely high. Before the year 2020 the ultimate development of the Snohomish Delta would occur with a self-maintaining floodway connecting the Possession Bay and Ebey Slough where the slough leaves the Snohomish River at about river mile 11. At this point a control structure would be constructed and the Snohomish River channel from river mile 11 to its mouth would no longer have the silt load as the river would be diverted through the floodway. This channel would be deepened to 20 feet from the Highway 99 Bridge to river mile 10 and from the mouth of the river to the Highway 99 Bridge the channel would be deepened to 46 feet. A large number of wet moorages would be provided through public small boat harbor projects with over 11 of these projects planned between 1980 and the year 2020 to supply 19,620 moorages. During this period all lands that were indicated in the navigation study as being suitable for terminal or water transport-oriented industrial development would be utilized for this purpose.

Power development would probably include pumped-storage at a number of the potential sites within the Basin. Oil or gas-fueled steam electric plants may also be located during this period to meet short-time peaking requirements. Development of nuclear electric generating plants may occur but specific sites have not been determined and would be dependent upon future studies that considered shoreline characteristics, nearness to major load centers and impacts on the environment.

The only additional flood control structures envisioned after 1980 would be levees to provide 100-year winter flood protection for the communities of Carnation, Gold Bar, Skykomish, Sultan, Monroe, and Snohomish. These projects, generally would be a matter of raising existing structures to heights sufficient to provide the 100-year protection. Flood plain management would be continued with zoning by the two counties which divide the Basin being required to guide future development and prevent unwarranted development in the flood plain. Additional floodway improvement would occur in the Snohomish Delta which would culminate in a self-maintaining flood channel from approximately river mile 11 near the head of Ebey Slough to the mouth of the river. The

channel would be straightened and gradually widen as it approached Puget Sound. Modification of the outlet works at the South Fork of the Tolt River storage project would be undertaken to gain some incremental flood control at the Snoqualmie system.

Further programs and projects would be undertaken to satisfy watershed management needs. These would include nine projects and a significant program of technical assistance and land treatment and water management.

Additional development of campgrounds, picnic areas, and other recreation facilities would be undertaken after 1980 at over 270 sites throughout the Basin, on public lands as well as on private lands, with both public and private sectors participating in the providing of recreation facilities. The recreation facilities provided at the North and Middle Fork Snoqualmie projects would be expanded commensurate with the growth in recreation use of these reservoirs. The tributaries of the Skykomish River may be included in a State system of scenic and recreational rivers for retention in a free-flowing state for public use. Also, the South Fork of the Snoqualmie and the Pilchuck Rivers could be included in the system as well as portions of the North and Middle Forks of the Snoqualmie River.

Additional fishing opportunities would be provided through anadromous and resident fishery enhancement measures. A number of fish passage improvements are planned during the long-range period as well as additional spawning habitat development. Wildlife preservation and enhancement programs begun prior to 1980 would be continued.

Table 7-19 summarizes the Snohomish Basin elements of the Comprehensive Plan, showing the benefits and costs for the early action portion of the Plan, and provides a summary of investment costs by water resource features for the entire 50-year period ending in 2020. The early action portion of the Plan includes programs amounting to \$111,409,000 and projects costing \$365,781,000 for a total investment of \$477,190,000. Program and project investment costs for the 1980-2000 period amount to \$376,725,000 and for the 2000-2020 period, \$378,905,000; for a total 50-year investment of \$1,232,820,000.

TABLE 7-19. Comprehensive Plan, Snohomish Basin

Feature	Items	1970-1980 Investment[1] Costs ($1000)	1970-1980 Average Annual Costs ($1000)	1970-1980 Average Annual Benefits Gross ($1000)	1970-1980 Average Annual Benefits Net ($1000)	1980-2000 Investment Costs ($1000)	2000-2020 Investment Costs ($1000)	1970-2020 Investment Costs ($1000)
Management Programs								
Water Quality Control	Monitoring, Evaluation and Control Programs	2,400	--	--	--	2,512	1,400	6,312
Flood Control	Flood Plain Management	55	--	--	--	100	100	255
Watershed Management	Programs	108,504	--	--	--	134,227	135,540	378,271
Fish & Wildlife	Programs	450	--	--	--	750	750	1,950
Total Programs		$111,409				$137,589	$137,790	$ 386,788
Nonstorage Projects								
M&I Water Supply	Ground Water Use	180	20	20[6]	0	0	0	180
	Surface Water Use	28,743[4]	2,512[4]	2,512[6]	0	64,382	19,465	112,590
Irrigation Water Supply	Ground Water Use	135	22	22[6]	0	135	0	270
	Surface Water Use	690	114	114[6]	0	392	175	1,257
Water Quality Control	Sewerage Treatment and Collection Facilities	97,390	4,588	4,588	0	32,480	43,700	173,570
Navigation	Channels	2,200	120	172	52	7,696	0	9,896
	Small Boat Harbors[3]	(6,306)[3]	(404)[3]	(585)[3]	(181)[3]	(9,725)[3]	(29,909)[3]	(45,940)[3]
Power[2]								
Flood Control	Channels and Levees	31,950	1,545	4,130	2,585	39,870[5]	36,255	108,075
Watershed Management	Floodwater Damage Reduction, Rehabilitation and Protection, and Water Management	2,503	142	397	255	12,387	100	14,990
Recreation	Land Acquisition, Access and Recreation Facilities	60,900	4,039	5,720	1,681	69,500	123,200	253,600
Fish & Wildlife	Land Acquisition, Access and Enhancement Facilities	8,797	987	2,728	1,741	12,294	18,220	39,311
Total Nonstorage		$160,988	$11,017	$17,331	$6,314	$239,136	$241,115	$ 641,239
Storage Projects								
	Culmback Dam (Sultan River)							
M&I Water Supply		6,798	318	350	32	0	0	6,798
Flood Control		8,642	443	707	264	0	0	8,642
Fish		7,604	369	500	131	0	0	7,604
	Total Project	$ 23,044	$ 1,130	$ 1,557	$ 427	$ 0	$ 0	$ 23,044
	North Fork Snoqualmie							
Power		32,845	1,798	1,867	69	0	0	32,845
Flood Control		12,138	665	690	25	0	0	12,138
Recreation		16,959	929	964	35	0	0	16,959
Fish		1,618	89	92	3	0	0	1,618
	Total Project	$ 63,560	$ 3,481	$ 3,613	$ 132	$ 0	$ 0	$ 63,560
	Middle Fork Snoqualmie							
Flood Control		25,088	1,169	1,657	488	0	0	25,081
Recreation		19,683	1,184	1,296	112	0	0	19,683
Fish		918	44	54	10	0	0	918
	Total Project	$ 45,689	$ 2,397	$ 3,007	$ 610	$ 0	$ 0	$ 45,689
Total Storage		$132,293	$ 7,008	$ 8,177	$1,169	$ 0	$ 0	$ 132,293
Total Program and Projects		$477,190	$18,025	$25,508	$7,483	$376,725	$378,905	$1,232,820

1 Includes cumulative annual program costs for the period for management features and capital costs for nonstorage and storage projects.

2 Power facilities not included in basin plan.

3 General Navigation facilities cost and benefits for public small boat harbors only. Total pleasure boat facilities costs and benefits included with Recreation.

4 Includes costs for additions to Everett's Sultan River transmission system.

5 Includes cost of modifying existing South Fork Tolt River project.

6 Average annual benefits assumed equal to average annual costs.

FEATURES OF THE COMPREHENSIVE PLAN

Municipal and Industrial Water Supply

Several water supply projects are planned for construction in the Snohomish Basin which are designed to satisfy the needs of the Cedar-Green Basins. These include a diversion dam on the North Fork Tolt River and transmission line, a transmission system from the North Fork Snoqualmie storage dam, second stage construction of the North Fork Snoqualmie project. These projects and the planned appropriation of water from the Snohomish Basin are covered in detail in the Cedar-Green Basins discussion.

The city of Everett now provides over 75 percent of the water consumed within the Snohomish River Basin and is expected to supply about this same proportion in the future to its service areas. The towns of Snoqualmie, North Bend, Carnation, Fall City, and other rural communities in the Snoqualmie Basin are anticipated to meet future growth in water demand by expanding their existing systems until such time as population density enables the city of Seattle to extend service to these communities. Likewise, most other rural communities within the Skykomish Basin would eventually be supplied by the city of Everett. Some of the more remote areas such as Skykomish and Index are anticipated to continue to use ground water over the 50-year planning period. The self-supplied water-using industries are located along the lower Snohomish River which provides an adequate supply of untreated industrial water. Major industrial water supply requirements within the Basin would be met entirely by the city of Everett with the exception of continued pumping from the Snohomish River by the Weyerhaeuser Company sulfite mill. Ground water supplies would continue to be utilized by rural communities and private residents in outlying areas.

The economies of a scale associated with water supply development by large water purveyors such as the cities of Everett and Seattle should provide the least cost source of water for smaller communities other than ground water or diversion from nearby streams. Also, the development by large water purveyors is considered to be in the overall best interests of environmental quality as a minimum number of possibly disruptive impoundments and structures are placed on streams, rivers and lakes. More of these resources are left in their natural state for the satisfaction of environmental needs than if each individual water district sought to satisfy its own needs through resource development. The communities of Snohomish and Monroe are included in the future Everett service areas. These communities at present are connected to the Everett system and satisfy a portion of their water requirements from this source. Edmonds, Lynnwood, and Mountlake Terrace are served by the Alderwood Water District which, in turn, is part of the Everett service area. Equitable wholesale water rates are necessary, however, to insure that cost savings are passed on to all those served by the large water purveyors. Without an equitable rate structure, suburban communities may in fact be able to develop their own water supplies at less cost.

The Snohomish Basin portion of the Comprehensive Plan dealing with municipal and industrial water supply is discussed by the following time periods:

1970-1980—The city of Everett's water system is capable of meeting projected needs, with allowance for minimum flows for anadromous fish below the existing Sultan River diversion dam, only to the year 1970, based on a firm flow requirement during a minimum runoff year. A requirement as contained in a Federal Power Commission Presiding Examiner's Initial Decision on June 7, 1968, to provide minimum fish flows of 50 cfs from June through September and 125 cfs from October through May, has resulted in a need for the city to advance its schedule of second stage development of Culmback Dam in the Sultan River Basin. Without the minimum flow for fish, the city would have a firm supply available from the current development on the Sultan through the year 1975. To meet the 1980 level of needs, construction of the second stage of Culmback Dam to maximum pool elevation 1,500 is recommended as a multiple-purpose project providing water supply for the city, low flow augmentation for fish and flood control. In addition to the storage project, the transmission system from the Sultan River to Lake Chaplain, as well as from Lake Chaplain to the distribution works near the city, must be expanded. A second tunnel between the Sultan River and Lake Chaplain is required before 1980, with a capacity of about 200 mgd. The existing tunnel at present has a capacity of 170 mgd which can be increased to 200 mgd by raising the height of the diversion dam through installation of radial gates. Additional transmission pipelines from Lake Chaplain to the city are

required to satisfy a peak day demand of approximately 300 mgd by 1980. Ultimate municipal and industrial use of the Sultan River water, on a firm flow basis, with provision for fish low flow augmentation in the amount of 50 cfs from June through September, and 125 cfs from October through May, would be an average daily flow of approximately 275 mgd. This will meet the city's needs to about 1990. The multiple-purpose storage project on the Sultan River is estimated to cost $23,000,000 with about $6,800,000 allocated to municipal and industrial water supply. Allocated annual costs to municipal and industrial water supply are $318,000 and benefits are $350,000. Investment costs for transmission facilities are estimated at about $24,150,000.

Additional ground water development in the amount of 3.0 mgd would require an investment of $180,000 and would meet a portion of the needs of small and rural communities. Installation of transmission lines from the Everett system would be required by some communities. Paper and allied products and food and kindred industries would add capacity to existing self-supplied water systems commensurate with projected output. The projected average daily water use for the Snohomish Basin, planned supply and transmission investments and average annual costs are shown in the following tabulation:

Development	Needed by Year	1980 Average Daily Water Use (mgd)	Supply, Transmission & Treatment Investment ($1000)	Average Annual Costs: Interest & Amort.[1] ($1000)	O&M[2] ($1000)	Total ($1000)	Benefits[3] ($1000)
Everett		204					
Second stage construction of Culmback Dam on Sultan River and transmission facilities	1970		30,948	1,447	852	2,299	2,331
Small and Rural Community Systems		17					
Additional ground water development	1970		180	14	6	20	20
Water purchased from Everett	1970		3,693	219	143	362	362
Self-Supplied Industry		42					
Surface water development	1978		900	69	100	169	169
Total		263	$35,721	$1,749	$1,101	$2,850	$2,882

1 Interest and amortization of capital investment costs.

2 Total incremental increase in annual operation and maintenance costs, including pumping and treatment costs.

3 Average annual benefits assumed equal to average annual costs except for Culmback Dam second stage storage project.

1980-2000—An expansion of the transmission system from Lake Chaplain to the distribution works would be required to provide for the peak daily flows of about 410 mgd associated with the firm average daily flow capability of 275 mgd. During this period, development would be required of a second water supply source. Pumping of water from the Snohomish River between river mile 20 and river mile 23 in conjunction with a large treatment plant constructed off the flood plain, on the slopes of Bald Hill, would supplement the Sultan River supply. The plant originally would be constructed to provide an average daily flow of approximately 90 mgd. This, combined with the 275 mgd from the Sultan, provides a total firm flow capability of 365 mgd which would meet the city's projected needs to about the year 2010. Associated with the treatment plant is the requirement for additional transmission lines from the treatment plant to the city's distribution works. Water drawn from the Snohomish and Sultan Rivers is anticipated to be supplied on a system basis to provide for maximum efficiency of operation. The investment cost for increasing the transmission capacity and constructing the pumping and treatment plant is estimated at $55,900,000.

The growth in small and rural community water use during this period beyond the capabilities of existing systems, would be met by the Everett and Seattle Water Departments. The self-supplied industries are expected to increase the capacity of their systems, consistent with projected output. A summary of projected average daily water use and investment costs is shown in the following tabulation for municipal and industrial water supply developments required by the year 2000:

Development	Needed by Year	2000 Average Daily Water Use (mgd)	Supply, Transmission and Treatment Investment ($1000)
Everett		321	
Increase transmission capacity of Sultan River system to meet peak daily demand of 410 mgd	1980		21,400
Construction of pumping and treatment plant adjacent to Snohomish River	1990		34,500
Small and Rural Communities		44	
Purchase water from Seattle	1985		4,280
Purchase water from Everett	1990		4,152
Self-Supplied Industry		50	
Surface water development	1990		650
Total		415	$64,382

2000-2020—Expansion of the Snohomish River treatment and pumping plant facilities would be required during this period to meet the needs to the year 2020. This would include expansion of plant and transmission capacity, estimated at an investment of $12,600,000, to provide an increase of 45 mgd average daily flow. Further expansion of transmission lines from the city of Everett's rural communities' system is expected. No further private water supply development is anticipated during this period by industry. A summary of projected average daily water use and investment costs is shown in the following tabulation for projects required by the year 2020. Service of south Whidbey Island in the amount of 9.2 mgd by 2020 is anticipated and would be met from the Everett water supply system.

Development	Needed by Year	2020 Average Daily Water Use (mgd)	Supply, Transmission and Treatment Investment ($1000)
Everett		410	
Expansion of Snohomish River pumping and treatment plant	2010		12,600
Small and Rural Communities		76	
Purchase water from Everett	2010		6,865
Self-Supplied Industry		50	
None			
Total		536	$19,465

Irrigation

Future irrigation development is expected to take place along the fertile bottom lands depending upon the flood protection provided and land use zoning implemented by county authorities. Irrigation development is anticipated to be by private means with individual farmers pumping from the major rivers or farm wells. The peak surface diversion demands of 103 cfs from the Snoqualmie River, 27 cfs from the Pilchuck and 54 cfs from the Snohomish, by 2020 can be met without adversely affecting other water uses.

The Comprehensive Plan provides for a net increase in the Snohomish Basin of 7,200 acres of irrigated land over the next 50 years for a total of about 20,000 acres in the Basin by the year 2020. About 11,300 acres of lands projected to be placed under irrigation would be offset by an expected elimination of 4,100 acres in the area north of Marysville due to urban development. Water required for the projected acreage in the Snoqualmie, Skykomish, and Pilchuck sub-basins would be diverted entirely from these respective rivers. In the Snohomish sub-basin, about 50 percent of irrigated land ultimately would be supplied by ground water.

Irrigation development as provided for in the Comprehensive Plan is discussed as follows:

1970-1980—Increased ground water use is planned and surface diversion with water pumped directly from adjacent rivers as tabulated below.

The private investment cost for the new surface water diversions is estimated at $135 per acre for a total investment cost of about $690,000 with total average annual charges, including interest and amortization, and operation and maintenance costs of $60,000, equal to $113,600. The investment costs include provisions for on-farm sprinkler system and pumping equipment. Increased ground water use in the Snohomish sub-basin will occur on an additional 1,000 acres of irrigated lands with 1,900 acre-feet of water supplied at a private investment cost of $135,000, with total average annual charges, including operation and maintenance costs of $12,000, equal to $22,500.

	1970-1980 New Irrigation		Diversion		Net Depletions	
Sub-Basin	Ground Water Supply (acres)	Surface Water Supply (acres)	Ground Water (acre-feet)	Surface Water (acre-feet)	Ground Water (acre-feet)	Surface Water (acre-feet)
Snoqualmie	--	3,300	--	6,300	--	4,000
Skykomish	--	600	--	1,100	--	800
Snohomish	1,000	500	1,900	1,000	1,300	700
Pilchuck	--	700	--	1,300	--	900
Total	1,000	5,100	1,900	9,700	1,300	6,400

1980-2000—During this period further diversion is planned with farmers continuing to pump from wells and directly from the rivers as shown below.

The private investment cost for the surface water diversions is estimated at $392,000. Increased ground water use in the Snohomish sub-basin will occur on an additional 1,000 acres of farmland with 1,900 acre-feet of water supplied at a private investment of $135,000.

	1980-2000 New Irrigation		Diversion		Net Depletions	
Sub-Basin	Ground Water Supply (acres)	Surface Water Supply (acres)	Ground Water (acre-feet)	Surface Water (acre-feet)	Ground Water (acre-feet)	Surface Water (acre-feet)
Snoqualmie	--	1,300	--	2,500	--	1,700
Skykomish	--	300	--	600	--	400
Snohomish	1,000	700	1,900	1,300	1,300	900
Pilchuck	--	600	--	1,100	--	800
Total	1,000	2,900	1,900	5,500	1,300	3,800

2000-2020—During the last twenty years of the planning period, only the Snoqualmie River Basin would require additional irrigation water with 1,300 acres of land receiving 2,500 acre-feet of water from the river. The estimated private investment cost of this diversion is $175,000.

Water Quality Control

The water quality control elements of the Comprehensive Plan are:

1970-1980 During this period the cities of North Bend, Snoqualmie Falls, Granite Falls, Index, Sultan, Monroe, Snohomish, and Everett would expand existing, or provide new, secondary treatment facilities.

Expansion of sewer systems is needed by most communities together with interception of industrial wastes. Removal of all settleable solids from pulp mill effluents prior to discharge and installation of adequate outfalls and diffusers to achieve maximum dilution and dispersion into Puget Sound, is included in the Plan. Urban areas developing between Edmonds and Everett and north of Marysville should be provided collection and treatment facilities on a schedule compatible with settlement with treated effluents discharged into Puget Sound. Collection of wastes, treatment and diversion from the Lake Steven's Basin is required.

The investment costs of waste treatment and collection facilities called for by 1980 are estimated below for industry, municipalities and recreational development within the Basin. Also shown are the program costs of water quality, monitoring, evaluation and control during this period.

The minimum 1980 flows required for assimilation of residual wasteloading, after secondary treatment, in the Snoqualmie—10 cfs, Skykomish—150 cfs, and the Snohomish—400 cfs, are available based on a review of minimum flows of record and anticipated diversions.

Water Quality Control
1970-1980

Feature	Investment Costs ($1000)	Average Annual Costs: Interest & Amortization[1] ($1000)	Average Annual Costs: Operation & Maintenance ($1000)	Average Annual: Total ($1,000)	Average Annual: Benefits[2] ($1000)
Monitoring, Evaluation and Control Program	2,400[1]				
Industrial Wastes					
Treatment	85,230	3,992	940	4,932	4,932
Municipal Wastes					
Treatment	3,390				
Sewers	7,900				
Subtotal	$11,290	$ 537	$124	$ 661	$ 661
Recreation Wastes					
Treatment	870	59	10	69	69
Total	$99,790	$4,588	$1,074	$5,662	$5,662

[1] Cumulative annual program costs for the period.

[2] Average annual benefits assumed to be at least equal to average annual costs.

1980-2020—During this period expansion by industry, new developments and growth of urban and recreation areas correspondingly would require that new sewer interception systems be installed and treatment facilities enlarged and/or constructed. Summarized below are estimated investment costs for water quality control by sectors for the periods 1980 to 2000 and 2000 to 2020.

Water Quality Control
1980-2020

Feature	Investment Costs ($1000) 1980-2000	2000-2020
Monitoring, Evaluation and Control Program	2,512[1]	1,400[1]
Industrial Wastes		
Treatment	10,300	23,200
Municipal Wastes		
Treatment	5,900	4,800
Sewers	13,680	11,200
Subtotal	$19,580	$16,000
Recreational Wastes		
Treatment	2,600	4,500
Total	$34,992	$45,100

[1] Cumulative annual program costs for the period.

The minimum 2020 flows required to meet water quality standards, for the Snoqualmie—25 cfs and the Skykomish—335 cfs, are adequately provided for in the Comprehensive Plan. A preliminary study of minimum flow records, anticipated consumption of Basin waters in the year 2020, including surface diversions for irrigation and municipal and industrial supply, indicates that a minimum flow of 500 cfs would be available in the Snohomish River to assimilate projected residual wasteloadings. Minimum flows for most years would be higher than this with a 7-day low flow of 500 cfs expected to occur not more than once every 30 years. The minimum flows of 750 and 890 cfs requested for 2000 and 2020, respectively, generally would be met with the exception of short periods during August and September occurring at infrequent intervals.

Navigation

The growth in commerce and associated water transport-oriented industrial development hinges in part on implementation of the "Snohomish River Basin Plan" prepared by the Snohomish County Economic Development Council. This plan has been adopted as part of the Comprehensive Plan. The Basin plan presents opportunities for balanced use of the Snohomish River delta and lands along the river to its head at the confluences of the Skykomish and Snoqualmie Rivers. Included are beach, park, and marine recreation facilities, additional deep water development taking advantage of the natural depths of Possession Sound, and creation of an extensive usable land area for a large port and industrial complex. Also provided for is a continuation of the existing greenbelt along the river through the urbanizing area. Floodways and flood plains afford recreational opportunities with portions of the delta and a slough to remain in a natural state for wildlife preservation.

The Snohomish River delta is an important potential site for water transport-oriented industrial and terminal expansion, one of only two large, relatively-undeveloped areas remaining along the eastern shores of Puget Sound. The Basin is served by three major railroads, affording shipping directions to the east, north and south, with Everett being a major assembly and distribution point for trains and the western terminus of Great Northern transcontinental railroad. Interstate Route 5 passes through Everett, paralleling the shores of Puget Sound, while U.S. Highway 2 provides all-year access to the east. At present, the Everett Port District includes only a portion of Snohomish County. This port district should be expanded to include the entire county as needed developments would involve large capital investments and necessitate a broad revenue base.

Navigation development as provided for in the Comprehensive Plan is discussed by the following time periods:

1970-1980—Additional land for water transport-oriented industry and deep draft terminals would be developed during this period. Lands along the Snohomish River portion of Everett Harbor to about river mile 9, together with that portion of Smith Island located west of Interstate 5, can be made available through land fill. An area designated as Tract Q, located immediately west and north of existing port terminal facilities and on the seaward

side of a training dike previously constructed by the Corps of Engineers, can be developed by depositing dredged materials from the Snohomish River channel. The dike provides some protection for a shallow draft navigation channel connecting Port Gardner with the Snohomish River. In order to provide access to Tract Q, a bridge would be required linking Smith Island with Tract Q or a causeway connection of Tract Q with Preston Point, the northern-most tip of the Everett Peninsula formed by Possession Bay and the Snohomish River.

Other lands located north of Marysville and south of Everett considered suitable for water transport-oriented industrial development (designated as sites 6, 7, and 8 in Appendix VIII, Navigation) are recommended for partial development during this period. These lands amount to over 4,900 acres.

Modification of the existing Federal project would be required by deepening the existing shallow draft channel to allow deep draft navigation from river mile 0.0 to the Highway 99 Bridge, using the dredged material for land fill. The East Waterway also would be dredged during this period to enable bulk carriers to serve the Basin. The planned channel improvements are tabulated below:

Navigation Improvements
1970-1980

				Average Annual			
				Costs			
Channel	Length (miles)	Depth (feet)	Investment Costs ($1000)	Interest & Amortization ($1000)	Operation & Maintenance ($1000)	Total ($1000)	Benefits ($1000)
Lower Snohomish River Deep Water to Highway 99 Bridge	3.5	32	1,921	90	15	105	138
East Waterway	0.7	46	279	13	2	15	34
Total	4.2		$2,200	$103	$17	$120	$172

The dramatic need for marine-oriented recreational facilities is evidenced by demand of over 4,000 new wet moorages for the Snohomish Basin by 1980. That portion of Tract Q set aside for waterfront recreational use and a site located at Meadowdale, north of Edmonds, are considered suitable for small boat harbor projects to meet the 1980 level of needs for public moorage. Meadowdale could be developed in its entirety, providing about 1,130 wet moorages. Tract Q with a potential for 3,080 wet moorages would be developed in two stages, with the first stage providing 2,000 wet moorages. The difference between the 3,130 wet moorages provided by public investment and the total demand of 4,000 is assumed for purposes of this Study to be met by further private investments.

The above is considered only tentative since many factors enter into small boat harbor developments with impacts beyond the capability of the planner to foresee. The investment costs and average annual costs and benefits of the public small boat harbor projects tentatively scheduled for construction by 1980 are tabulated below:

Small Boat Harbor Projects
1970-1980

Location	Wet Moorages	Investment Costs ($1000)	Average Annual[1] Costs ($1000)	Average Annual[1] Benefits ($1000)
Tract Q	2,000	4,000	268	374
Meadowdale	1,130	2,306	136	211
Total	3,130	$6,306	$404	$585

[1] General navigation facilities costs and benefits only, based on 50-year economic life amortized at a 4-5/8 percent interest rate. Total pleasure boat facilities costs and benefits included with Recreation.

1980-2000—Further development of the Snohomish Delta is envisioned during this period. Industrial and terminal areas of Tract Q would be increased by land fill of the western portion of this site. Additional industrial lands could be made available through dredge fill and construction of perimeter levees on portions of Smith Island not developed by 1980. The dredge material would be derived from the channel improvement, with increased channel dimensions offsetting the reduction in flood plain area caused by land reclamation.

A navigation project is proposed for increasing the draft of the channel dredged prior to 1980 and also increasing the shallow draft channel from a depth of 8 feet to 20 feet in the Snohomish River from the Highway 99 Bridge to river mile 10. The channel projects would be necessary to enable deeper draft vessels, both freighters and barges, to serve the port area.

The planned channel improvements are tabulated below:

Navigation Improvements
1980-2000

Channel	Channel Dimensions Length (miles)	Channel Dimensions Depth (feet)	Investment Costs ($1000)
Lower Snohomish River from deep water to Highway 99 Bridge	3.5	46	3,511
Upper Snohomish River from Highway 99 Bridge to River Mark 10.0	7.0	20	2,313
East Waterway	0.8	78	1,872
Total	11.3		$7,696

Significant increases in small boat harbor development are forecast for this period with over 5,900 wet moorages to be provided, including moorages to satisfy spillover demand from the Cedar-Green Basins. Any of a number of sites shown in Appendix VIII, Navigation, can be developed, with the exact location of new wet moorages during this period depending upon local interest, availability of funds, and other factors. The public small boat harbor projects scheduled prior to 2000 are tabulated below:

Small Boat Harbor Projects
1980-2000

Location	Wet Moorages	Investment Costs ($1000)
Tract Q Addition	1,080	2,255
Big Gulch	1,310	2,620
Edmonds North	2,350	4,850
Total	4,740	$9,725

2000-2020–By this period, demand for further industrial development would increase land values in the delta sufficiently to justify a major modification of the flood channel to provide essentially a single outlet for floodwater passage from river mile 11, near the head of Ebey Slough, to Possession Bay. The present Snohomish River channel downstream of river mile 11 would be cut off by a structure, becoming relatively maintenance free for shallow draft navigation. The flood channel would be designed for self-maintenance. This improvement could occur prior to the year 2000, depending on the rate of port and industrial development in the delta.

Additional land having flood protection of over 100-year frequency would be made available for water transport-oriented industries by this project. Other lands suitable for water transport-oriented industrial development, which may be partially developed during this period, include over 19,000 acres contained within the Tulalip Indian Reservation located north of the delta.

Spillover of unsatisfied demand for wet moorages from the Cedar-Green Basins would require full development during this period of sites found within the Basin to be suitable for small boat harbors. Projects providing wet moorages planned for public development are tabulated below:

Small Boat Harbor Projects
2000-2020

Location	Wet Moorages	Investment Costs ($1000)
Tulalip Bay–Phase One	1,320	2,640
Tulalip Bay–Phase Two	2,390	4,780
Priest Point West	5,140	10,429
Mukilteo	1,100	2,200
Picnic Point North	1,730	3,460
Port Susan-Warm Beach	1,400	2,800
Mukilteo South	880	1,760
Norma Beach North	920	1,840
Total	14,880	$29,909

Power

The electrical energy needs of the Basin are satisfied on a regional basis with over 85 percent of the energy imported in 1965 from outside the Puget Sound Area. Energy produced by the only operating hydroelectric project within the Snohomish Basin, Snoqualmie Falls No. 1 and No. 2, is supplied to the network grid through interconnections. Adequate power is forecast from existing sources to satisfy Area needs up to 1980; however, increased power generation would be necessary from local plants to meet the 2000 and 2020 loads.

Three hydroelectric projects are under active consideration within the Basin. One project is part of a multiple-purpose development, recommended in the Comprehensive Plan, that would be constructed on the North Fork of the Snoqualmie River with two powerhouses, one integral with the main storage dam and the other located downstream of a reregulating dam for a total installed capacity of 60,000 kilowatts. This project would be capable of producing about 265,000 kwh of electricity annually. The investment costs allocated to power are estimated at $32,845,000. Average annual power benefits are estimated at $1,867,000 as compared to average annual costs of $1,798,000. Another project under consideration is the Sultan River project, Culmback Dam. The third is the Pilchuck River project by the

city of Snohomish with 4,000 kilowatts of capacity.

The Sultan River project, as licensed by the Federal Power Commission, is a multiple-purpose project with provisions for water supply, future hydroelectric power, recreation, and future downstream releases for fish. A joint application filed by Public Utility District No. 1 of Snohomish County and the city of Everett resulted in a license being issued on June 1, 1961, as amended June 7, 1968, to the joint applicants for construction, operation, and maintenance of the project. The license provided for construction of the project in two stages. Stage I, constructed during the period 1962 through 1964, provides additional water supply for the city and includes a reservoir with a maximum operating level at elevation 1,360. Stage II of the project as set forth in the license would include the raising of the dam to accommodate a reservoir with a maximum operating level at elevation 1,450 and all features required for hydroelectric generation and for fish water releases during noncritical flow periods. A provision of the license as issued was the requirement that construction of Stage II be commenced within six years from the date of issuance of the license or by June 1, 1967. However, licensees applied for an extension of time for starting construction of Stage II until up-to-date studies of the proposed enlargement was completed. FPC hearings were conducted on the extension during May 1969. However, no final ruling has been made at the time of this report. Studies performed by consultants to Snohomish PUD, assuming BPA rates remain at current levels, have indicated that the cost of power from the Sultan project as envisioned in the license would exceed the cost of the alternative supply from Bonneville. The consulting engineers for the District have indicated that a power intake could be installed at Culmback Dam after second stage construction when and if provision for power becomes desirable. Consequently, early action on hydroelectric power development at this project is not included as a feature of the Comprehensive Plan.

Base-load nuclear electric generating plants are anticipated at a number of locations within the Puget Sound Area between 1980 and 2000. Exact locations have not been determined except in a few instances, but the Snohomish Basin may receive consideration for site selection due to shoreline characteristics and nearness to major load centers.

Oil or gas-fueled steam electric plants may be located within the Snohomish Basin to meet the Area's short-time peaking requirements. A number of pumped-storage hydroelectric sites which may be developed to supplement peak load supply exist in the upper drainage of the Basin.

Proposed development of any plant would require that adverse impacts on the environment be considered and the means provided to lessen these impacts or mitigate their effects when specific project studies are undertaken. Thermal-power generation is discussed further under Puget Sound Area.

Flood Control

Elements of the Comprehensive Plan would reduce flood damages in the Snoqualmie Basin, portions of the Skykomish Basin, and along the flood plain of the Snohomish River below the confluence of the Snoqualmie and Skykomish Rivers. Flood protection objectives for the three sub-basins would be generally met by the elements proposed in this Plan. These objectives have been defined in terms of flood frequencies with industrial and urban lands within the Basin recommended for 100-year level of flood protection, agricultural lands requiring at least 25-year level of protection, and lands along the flood plain to be used for parks, golf courses, and general recreation requiring a level of flood protection of 10 to 15 years.

Flood plain management measures including flood-proofing, flood plain zoning, and other positive means of land use control are important means for reducing the growth of future flood damages. Sufficient lands are considered available within the Snohomish Basin to preclude the necessity of intensive development in the flood plain; however, without flood plain zoning structural measures may be needed beyond those provided in the Plan. Uncontrolled encroachments on the flood plain by residential and industrial developments would require expensive structural flood control measures to protect these high value investments.

The portion of the Comprehensive Plan dealing with flood control is discussed below:

1970-1980—Multiple-purpose storage projects on the North and Middle Forks of the Snoqualmie River would provide significant flood control. These projects would provide 170,000 acre-feet of flood control storage and would control floods in sufficient degree to allow urban and suburban use of the valley in the vicinity of Snoqualmie Falls and North Bend. Downstream of Snoqualmie Falls, floods would be controlled sufficiently to reduce flood damages to farms and roads, permitting substantial increases in

agricultural returns. Implementation of flood plain zoning to control developments within the limits of the flood protection provided would result in about 10,000 acres of floodprone land in the Snoqualmie River Basin being retained for open space recreation and agricultural use. These projects would also benefit the lower Snohomish River Basin by reducing flood damages on agricultural lands and enabling industrial development of the Snohomish River delta in conjunction with other structural measures. Adjustments of the existing floodway in the Snohomish River delta would be accomplished during this period by enlarging the main channel and the various sloughs to the extent justified by the industrial development anticipated for the area. The investment costs allocated to flood control from the North and Middle Fork projects are estimated at $12,138,000 and $25,088,000, respectively, out of total project costs of $63,560,000 and $45,689,000. Average annual flood control benefits are estimated at $690,000 as compared to average annual costs of $665,000 for the North Fork project, with the average annual flood control benefits estimated at $1,657,000, substantially exceeding the average annual costs of $1,169,000 for the Middle Fork project.

Culmback Dam on the Sultan River is one of only four sites available for major potential flood control storage in the Basin and is the most downstream of any possible flood storage project; therefore, would have the greatest benefit for the lower Snohomish River. Flood control storage of 100,000 acre-feet from the Sultan River Project would reduce major flood flows in the Snohomish River by about 20,000 to 25,000 cfs. Preservation of storage space for flood control is a winter period requirement when base flows and the rivers are usually high. This flood control storage space is usable for conservation storage to meet fish and municipal and industrial water requirements during the remainder of the year. Preliminary studies have indicated that some portion or all of the 100,000 acre-feet could be used for conservation storage during most years. Adding flood control as a project purpose requires the addition of an outlet control works and discharge conduit. The outlet works would be used to maintain bank-full discharges for excavation of storage space between floods. Flood releases would be limited to approximately 14,000 cfs, the nondamaging channel capacity of the Sultan River downstream from the project. The allocated cost for flood control from the second stage Sultan River project is estimated at $8,642,000 out of a total project cost of about $23,000,000. Preliminary economic analysis provides estimates of average annual benefits and costs at $707,000 and $443,000, respectively; however, detailed studies are needed to provide estimates of benefits and costs suitable for a survey report required to obtain Congressional authorization of Federal participation in a second stage development of the Sultan River project. A final disposition by the Federal Power Commission of the request for an amendment to the existing license with regard to minimum releases for fish in the Sultan River would be required to complete the evaluation of project benefits and provide the basis for an allocation of joint costs among the project beneficiaries. Studies performed in 1963 indicated that flood control is compatible with operation of the Sultan River project for power which could be added at some future date without diminishing the flood control benefits available from the project.

Other flood control structural measures recommended for construction prior to 1980 include setting back the levees along the Snohomish River now providing protection to the Marshland and French Creek agricultural areas. These levees were part of a project authorized by Public Law 566, approved in 1959, which involved raising the existing levees and constructing drainage channels and pumping plants. The restricted width between the levees limits the opportunities for improving flood channel capacity and flood protection. Currently, these levees are providing only limited protection against river topping. The Snoqualmie River storage projects, together with flood control storage from the Sultan River project and levee setbacks at the French Creek and Marshland Drainage Districts, would reduce the frequency of winter peak flows that flood the Districts at a current reccurrence interval from once every 2 to 4 years to once every 25 years. Setting back of the levees from Snohomish River Mile 10 to River Mile 18.5 prior to 1980 at an investment cost of $6,300,000, with average annual costs of $315,000 compared with average annual benefits of $400,000.

Channel improvements in the Snohomish River estuary are necessary to compensate for lands removed from industrial development in the Snohomish Delta. These improvements are planned for early action with a portion of Steamboat Slough down-

stream from Interstate Highway 5 crossing recommended bringing out self-maintaining aspects for straightening and widening to compensate for lands removed from the floodway. This work has an estimated cost of $25,650,000 and would provide a channel capacity of 113,000 cfs, with which the industrial lands made available from dredging would receive flood protection from at least 100-year frequency floods. Dredged materials from the channel could be deposited to raise the level of lands on Smith Island located between Steamboat Slough and the Snohomish River main channel. Average annual project costs of $1,230,000 compared with average annual benefits of $3,730,000.

The tabulation below summarizes the early action flood control programs and projects for the Snohomish Basin:

Flood Control Element	Effective Flood Control Storage (Ac.Ft.)	River Mile	Height of Dam (Ft.)	Design Capacity (cfs)	Invest. Costs ($1000)	Average Annual[1] Costs Interest & Amort. ($1000)	O&M ($1000)	Total ($1000)	Benefits ($1000)
Flood Control Storage Projects									
North Fork Snoqualmie River	50,000	11.0	300		12,138	628	37	665	690
Middle Fork Snoqualmie River	120,000	10.0	190		25,088	1,136	33	1,169	1,657
Sultan River	100,000	14.0	265		8,642	403	40	443	707
Channel and Levee Construction									
Estuary Channel Snohomish River Mouth of Snohomish River to River Mile 3.0				113,000	25,650	1,200	30	1,230	3,730
Setback existing levee from River Mile 10.0 to River Mile 18.5				90,000	6,300	310	5	315	400
Subtotal					$77,818	$3,677	$145	$3,822	$7,184
Flood Plain Management					55[2]				942
Total					$77,973				$8,126

1 Allocated flood control costs and benefits shown for storage projects.

2 Cumulative program costs for the period.

1980-2000 During this period, the only additional flood control structures envisioned are the construction of levees to provide 100-year winter flood protection for the communities of Carnation, Gold Bar, Skykomish, Sultan, Monroe, and Snohomish. These projects, in many cases, would be a matter of raising existing structures to heights sufficient to provide the 100-year protection. Development anticipated in these communities by this period would be sufficient to economically justify the additional levee work. The levee projects are tabulated below with estimated investment costs:

Snohomish Basin Levee Projects
1980–2000

Location	Length of Levee (miles)	Investment Costs
Carnation	2	200,000
Gold Bar	3	1,500,000
Skykomish	1	200,000
Sultan	3	1,500,000
Monroe	3	1,500,000
Snohomish	1	500,000
Total	$13	$5,400,000

Additional floodway improvements in the Snohomish Delta are anticipated after 1980 consistent with the industrial development. Further adjustment to Steamboat Slough is envisioned with straightening and widening upstream from Interstate Highway 5 to its junction with the Snohomish channel at or near River Mile 6, at an estimated cost of $32,470,000. The increased channel dimensions would provide 113,000 cfs capacity and would offset the reduction of the flood plain area caused by land reclamation. The dredged materials from the floodway could be used for levee construction and filling on Smith Island above the freeway. Modification of the outlet works to gain 15,000 acre-feet of additional flood control storage on the South Fork of the Tolt River is expected to be justified during this period by flood damage reduction benefits resulting from economic growth in the flood plain. This modification will cost an estimated $2,000,000. Flood plain management costs over the period are estimated at $100,000.

2000-2020 During this latter period, full development of the Snohomish River Delta would be required to provide industrial lands commensurate with the growth of the area. The floodway channel extension would be required with the reshaping of the existing channel and drainage patterns of the Delta area to provide 100-year flood protection. From approximately River Mile 11 near the head of Ebey Slough, the channel downstream would be straightened and gradually widened as it approaches the Sound. This would intercept the project extension provided during the period 1980 to 2000 resulting from the straightening of Steamboat Slough. The channel would be designed as a self-maintaining channel, with a 113,000 cfs flood-flow capacity at an estimated cost of $36,255,000. This and the previous channel modifications are anticipated to be justified by the land enhancement values derived from the industrial sites made available in the Delta. Flood plain management costs over this period are estimated at $100,000.

Watershed Management

The needs for watershed management in the Snohomish Basin would be satisfied by continuing and accelerating soil and water conservation programs and installing projects for reduction of floodwater damage, protection and rehabilitation of watershed lands, and water management measures such as agricultural and urban drainage. A considerable amount of urban development is anticipated in the western portion of the Snohomish Basin, while the areas at higher elevations are expected to remain in forest. About 379,000 acres located outside the boundaries of the National Forests are in Land Use Capability Classes II through VI. These lands have a strong potential for agricultural use. Where these lands are located in flood plains or other hazardous areas, they should be retained as cropland or in other open land use for a variety of productive, economic and environmental quality reasons, including retention of options for use in the future.

The watershed management projects included in the Comprehensive Plan for the Snohomish Basin are complementary to the major flood control projects also contained within the Plan. A number of measures made possible by structural works of improvement are recommended for implementation, such as seeding of improved grasses and legumes, growing of cover crops, urban drainage development, and forest management practices. A continuing investment is required, both public and private to insure protection of the water and related land resources within the Snohomish Basin. This investment would be in the form of financial and technical assistance, research, education, and information. While the

acreage requiring treatment remains fairly constant by time periods, the intensity of treatment application and the composition of the combined measures varies with the inherent capability of the land as well as with the kind and intensity of use.

Federal and State land administrative agencies are responsible for the installation of applicable measures on land assigned to their management, while the initiative of individual property owners is required for installation of practices on lands in private ownership. Various Federal and State agencies have programs of technical and financial assistance for individuals, local organizations, and subdivisions of government, including King County Soil and Water Conservation District and Snohomish County Soil and Water Conservation District. The schedule of watershed management projects and programs provided for in the Comprehensive Plan is discussed as follows:

1970-1980—Several projects planned to remedy existing floodwater and drainage problems are briefly described below:

Patterson Creek Watershed.—The flood plain of this watershed is narrow throughout most of its length, broadening at its juncture with the flood plain of the Snoqualmie River. Most of the land has been cultivated, and the hills on either side of the streams are heavily forested with stands of Douglas fir and alder. Urban developments are beginning to appear throughout the higher portions of the watershed.

The project is designed for flood prevention of agricultural and urban areas with drainage of agricultural lands and would consist of 8 miles of improved and stabilized channel for Patterson Creek along with one water control structure to stabilized the water table in organic soils. Installation costs are estimated to be $392,000 of which the Federal share is $265,000 and the local share is $127,000. To achieve benefits resulting from damage reduction and drainage, local interests would be required to install necessary land treatment measures for erosion and flood management costing approximately $918,000, drainage measures estimated at $298,000, and forest protection and management practices costing over $1,000,000 for a total investment of $2,226,000, making the entire cost of installing the structural and land treatment measures $2,618,000. The projects average annual benefits of $33,000 are compared with the average annual costs of $21,300 including $3,000 for O&M.

Snohomish Estuary Watershed.—This watershed is located north and east of Everett bordering partly on the Snohomish River downstream from the town of Snohomish, with the flood plain of the river and the low hills on either side, along with several islands in the river, being included. The flood plain is nearly all farmed and grassed for pasture, while the higher portions are urbanized or covered with brush forest. The forest areas are limited to the few high ridges where young stands of Douglas fir and red alder grow.

The project is designed for flood prevention of agricultural and urban areas and drainage of agricultural lands, and consists of 15 miles of improved and stabilized channel, three outlet structures including flood gates and pumps, 13 improved flood gate structures, and 11 miles of new and reconstructed dikes along Ebey Slough.

Installation costs are estimated to be $2,111,000, of which the Federal share is estimated at $1,617,000 and the local share $494,000. To achieve benefits resulting from damage reduction and drainage, local interests would be required to install necessary land treatment measures for erosion control and flood management costing $744,000, drainage measures estimated at $1,895,000, and forest protection and management practices costing $140,000 for a total investment of $2,780,000. The project's average annual benefits of $363,800 are compared with average annual costs of $120,700 including $22,000 for O&M.

Programs tabulated below include the complimentary features of the projects discussed above and other on-farm and urban on-site practices required in the Snohomish Basin. Non-Federal costs include costs of on-going programs of development and treatment with redirection and acceleration to meet needs. Total costs are shown.

Watershed Management Practices
1970-1980

Program	Area (acres)	Cost ($1000)
Technical assistance		
and management	1,128,875	
Federal, regular		19,823
Federal, accelerated		641
Subtotal		$ 20,464
Installation of practices (non-Federal)		
State and corporate		14,428
Land treatment	599,442	7,096
Water management		
Agricultural	25,718	7,994
Urban	43,350	58,522
Subtotal		$ 88,040
Total		$108,504

1980-2000—The programs and projects scheduled for this period are tabulated below, with estimated installation costs.

Watershed Management Practices
1980-2000

Program	Area (acres)	Cost ($1000)
Technical assistance		
and management	1,113,623	
Federal, regular		41,209
Federal, accelerated		1,496
Subtotal		$ 42,705
Installation of practices		
(*non-Federal*)		
State and corporate		19,238
Land treatment	584,190	8,726
Water management		
Agricultural	17,145	5,036
Urban	43,350	58,522
Subtotal		$ 91,522
Total		$134,227

Project[1]	Area (acres)	Structural Measures Installation Cost ($1000)
Snoqualmie River	424,360	2,280
Skykomish River	426,616	720
Wood Creek	40,880	500
Pilchuck River	78,454	1,000
Cathcart Area	8,897	600
Snohomish Estuary	24,463	6,890
Tulalip-Warm Beach	26,437	250
Lake Stevens[2]	5,310	147
Total	1,035,417	$ 12,387

[1] The small watersheds of the Snohomish Basin are shown on maps contained in Appendix XIV, Watershed Management.

[2] A small watershed project for flood control added to projects contained in Appendix XIV, Watershed Management, which would provide a weir and new outlet channel about 4,000 feet long, designed to stabilize the stage of Lake Stevens within a range of about one foot above the weir crest and improve total drainage. The project is under current study and may be constructed prior to 1980 depending upon the availability of funds and the findings relating to economic and engineering feasibility contained in a detailed project report under preparation by the Corps of Engineers.

2000-2020—The programs and projects planned for implementation during this period are shown in the following tabulation:

Watershed Management Practices
2000-2020

Program	Area (acres)	Cost ($1000)
Technical assistance		
and management	1,064,540	
Federal, regular		42,628
Federal, accelerated		214
Subtotal		$ 42,842
Installation of practices		
(non-Federal)		
State and corporate		19,238
Land treatment	535,107	8,141
Water management		
Agricultural	18,000	6,797
Urban	43,350	58,522
Subtotal		$ 92,698
Total		$135,540

Project	Area (acres)	Structural Measures *Installation* Cost ($1000)
Sultan River	68,949	100

Recreation

The fifty miles of salt-water shoreline, many miles of rivers and streams, and numerous lakes within the Snohomish Basin can support an expansion of recreational developments. Additional campgrounds and picnic areas are planned on National Forest lands in the Basin's eastern half and on State lands in the central portion; however, partial constraints to full development of the outdoor recreation opportunities are foreseen with the spread of urban and industrial development, together with the presence of railroad track along the marine shoreline from Everett south. Two large municipal watersheds

lie within the Basin. With over 1,900 square miles of land, the 78-square mile Sultan River watershed and the 20.9-square mile South Fork Tolt River watershed are not currently needed for public recreation satisfaction and are viewed as reserves for future recreation use.

Through the development of suitable areas on existing publicly-administered lands, approximately two-thirds of the projected picnicking and camping needs for the year 2020 can be met. Private land acquisition would be required to obtain special recreation sites and to supplement the existing public lands, which must remain in public ownership to insure availability.

The broad recreation goal is to promote well-planned development and protection of the existing resources and to provide an opportunity for the satisfaction of present and future outdoor recreation demands of the population. Based on Federal ownership of land, plans and programs of recreation suppliers, and expected population concentrations as well as outdoor recreation needs, the assumption is made that the Federal agencies would provide 30 percent of the future required water-related opportunities, while the State, county and local agencies, and the private sector, would supply 20, 30, and 20 percent respectively.

The recreation development as discussed by the following time periods is intended to be compatible with the Washington State Outdoor Recreation and Open Space Plan.

Additional facilities and acquisition and development of land and water areas are required in order to satisfy the water related outdoor recreation needs. The specific land and water area requirements are shown in the tabulation below.

1970-1980—Recreational developments are planned in conjunction with the multiple-purpose storage projects planned for the North and Middle Forks of the Snoqualmie River. Four recreation areas are proposed for development at the Middle Fork project with four sites also planned at the North Fork project. The reservoirs would be operated and administered for recreation through stabilizing of pool fluctuations, landscaping, proper forest management, and the development of camping and picnicking facilities. A stable conservation pool would be maintained on the Middle Fork Reservoir during the months of June through September, the summer recreation season. Tentatively, the reservoir would be drawn down 10 feet or less during this period to augment downstream low summer flows for fish. Actual schedules of draw down to provide flow for fish would be determined from detailed project studies. Stumps and debris would be removed from the lakes within the limits of the summer draw-down and in the bathing beach areas with natural scenic beauty of the shoreline being carefully preserved. Similar provisions would be made for the North Fork Reservoir. The scenic reservoirs form attractive recreational areas in a mountain setting within a driving distance of less than one hour from the major urban centers of Seattle and Everett. Easements would be

Recreation Land and Water Requirements
1960-2020

Activity	Unit	1960 Land	1960 Water	1980 Land	1980 Water	2000 Land	2000 Water	2020 Land	2020 Water
Swimming									
Beach Area	Acres	0	0	8	2	43	6	113	16
Pools	Sq.Ft.	144,000	72,000	316,000	158,000	646,000	323,000	1,237,000	619,000
Boating, Sailing									
& Water Skiing	Acres	33	0	113	11,768	303	81,768	638	251,768
Camping	Acres	554	---	1,364	---	2,764	---	5,464	---
Picnicking	Acres	357	---	537	---	937	---	1,637	---
Hiking	Miles	0	---	0	---	218	---	718	---

Source: Appendix X, Recreation.

obtained along the river banks below the dams to preserve access for fishermen and for other outdoor recreation activities. Stocking of the reservoirs would occur annually from a hatchery provided as part of the project. With proper planning and emphasis on aesthetic features, these storage projects could be made to blend into the existing environments, becoming attractive recreational assets to the Basin. The investment costs allocated to recreation from the Snoqualmie projects are estimated at $36,642,000, with average annual costs of $2,113,000 and average annual benefits of $2,260,000.

Other developments calling for early action include construction of small public boat harbors. These harbors would provide wet moorages to meet pleasure boating needs. Private investment also would be necessary to meet both wet and dry moorage needs. Development of Tract Q as discussed under Navigation would provide 160 acres of marine shoreline for public recreation use which, in the form of beaches and public moorage, would satisfy an important part of the demand for marine-oriented outdoor recreation with planned initial development of recreation access on Tract Q and Smith Island, providing about two miles of road for this purpose. Other elements for recreation development include improvements and rehabilitation of developed facilities on the public-administered recreation areas within the Basin, which number approximately 110. A portion of the 550,000 acres of publicly-adminstered undeveloped Class III general recreation lands are recommended for development during this period.

Designation of network of scenic roads to provide travel links between recreation attractions which would enhance driving for pleasure and sightseeing opportunities also is recommended for early action. These roads would be included within a State-wide system of scenic roads. Additional sites along the marine shoreline should be investigated for suitability for acquisition and development as saltwater parks. Over 100 recreation areas are planned for expansion or development before 1980. Preservation of the natural flood plains along the Snohomish, Skykomish, and Snoqualmie Rivers as open space is recommended, consistent with the portions of the Comprehensive Plan discussed under Navigation and Flood Control. Land use zoning is viewed as essential to insure that these lands would be retained for this purpose.

A State system is suggested to retain important recreation rivers or river segments in their natural free-flowing state, with the North, South and Middle Forks Snoqualmie, Skykomish, Wallace, Beckler, Miller, Foss, Tyee, and Pilchuck Rivers recommended for study to determine if these streams or portions thereof may qualify for protection. Retention of outstanding natural areas and historical and archeological sites identified in Appendix X, Recreation, for the Snohomish Basin would not conflict with other elements of the Comprehensive Plan and are included for inspirational and educational purposes and general enjoyment of the people.

Investments for recreation facilities other than those discussed previously are tabulated below for the various water-related improvements:

Outdoor Recreation Improvements
1970 to 1980

		Average Annual			
		Costs			
Feature	Investment Costs ($1000)	Interest & Amortization ($1000)	O&M ($1000)	Total ($1000)	Benefits ($1000)
Campgrounds	19,096				
Picnic Areas	2,254				
Beaches	96				
Swimming Pools	3,950				
Boating Facilities	11,865				
Planning & Design	9,315				
Land Acquisition	14,324				
Total	$60,900	$2,848	$1,191	$4,039	$5,720

1980-2000—During this period, further development is anticipated with expenditures for improvements and developments estimated at $52,000,000 and $17,500,000 for land acquisition, including buffer zones. Additional facilities would be provided at the North and Middle Forks of the Snoqualmie projects, commensurate with the growth in recreational demand. Expansion of the marine recreational shore facilities at Tract Q and developments on other marine shoreline sites acquired by 1980 would be required. About 125 recreation areas are planned for expansion or new development.

2000-2020—After the year 2000, more extensive development of public land is anticipated. Retention of public-owned properties held at present and the acquisition of additional lands required to satisfy marine recreational needs are assumed. With proper public land management and the use of waterfront access leases, large scale acquisition of private lands is not foreseen as being necessary to meet the future needs. Expansion of recreation facilities is planned at existing lakes and the North and Middle Fork reservoirs as well as extension of marine shorelands at Tract Q. Scenic drives and recreation access to the Snohomish River estuary would be provided along the floodway as proposed in the Comprehensive Plan. The program for recreation development combined with complimentary fish and wildlife features would meet the future recreation needs of the Snohomish Basin as well as supplying spillover demand from the more populous Cedar-Green Basins. Total recreation development costs during this period are estimated at $90,000,000 and $33,200,000 for land acquisition, including buffer zones. Approximately 150 recreation areas would be expanded or developed during this latter time period.

Fish and Wildlife

The Snohomish Basin offers numerous opportunities for projects and programs that, if implemented, would maintain and increase fishing and hunting opportunities. Fish and wildlife elements of the Plan are discussed as follows:

1970-1980—Important measures for the enhancement and preservation of fish planned for early action include the release of minimum flows in the Sultan River of 50 cfs from June through September and 125 cfs from October through May below the existing diversion dam. Fish enhancement benefits derived from these minimum releases would be derived from second stage construction of Culmback Dam to elevation 1,527 (see discussion under Municipal and Industrial Water Supply and Flood Control). Flows exceeding these minimums could be made available for fish initially with construction of the second stage project. Gradually, however, with growth in water supply demand, the amount of water for fish would decrease and in low runoff years approach the specified minimums. The allocated costs to fish for low-flow augmentation benefits are estimated at $7,604,000 with average annual costs of $369,000 and are based on preliminary studies performed in 1963 updated to 1968 dollars. Average annual benefits of $500,000 also are based on 1963 studies. Additional fish benefits would be derived from flood control and low flow augmentation provided by the North and Middle Forks Snoqualmie projects. Allocated investment costs to fish for enhancement measures are $1,618,000 for the North Fork project and $918,000 for the Middle Fork project with average annual costs of $89,000 and $44,000, respectively. Augmentation of low summer flows will provide an increased rearing area in the lower river downstream from Snoqualmie Falls for salmon and steelhead trout. On an average annual basis 13,500 and 7,800 user-days and 136,500 and 88,400 pounds of commercial fish, respectively, would result from the North and Middle Fork projects. Economic benefits amount to $104,000 and $64,000 from the respective projects.

Another major enhancement project included a barrier dam and collection facilities below Snoqualmie Falls with provisions for trucking adult salmon above the Falls at an estimated cost of $1,400,000. Increased production by implementation of this project is estimated at 76,000 adult chinook and coho salmon. Two spawning channels would be constructed during this period, each approximately one mile in length, for a total initial investment cost of $1,400,000. These channels would enhance the pink and chum salmon runs with a total production increase amounting to nearly 360,000 adult fish.

Construction of steelhead rearing ponds on the Sultan and Skykomish Rivers is called for at an estimated cost of $500,000 to produce 750,000 downstream migrants, resulting in an increase of an average of 125,000 annual user-days of sport-fishing activity. Clay slide problems in the Taylor and Middle Fork Snoqualmie Rivers would be corrected as part of the multiple-purpose Middle Fork Snoqualmie

project, resulting in an average annual increase of 10,000 sport-fishing user-days.

Access at 13 small lakes within the Basin is planned along with picnicking, parking, and other facilities, at an estimated investment cost of $490,000 with an average of 107,000 annual user-days of recreation benefits derived from this investment. A trout hatchery to stock lakes is planned for construction at a cost of $437,000 as well as development of new fish toxicants and lake fertilizers to improve the productivity of user-days of sport-fishing activity. Acquisition of land or the obtaining of long-term leases for streambank access on 50 miles of the Basin's major tributaries is called for at an estimated cost of $800,000, providing an average of 27,400 annual user-days of activity. Cross-sectional streams surveys needed to determine the minimum and optimum flows for resident and migratory fish are scheduled prior to 1980. These would be undertaken throughout the Area (see Fish and Wildlife under the Area Discussion by Feature). A second trout hatchery to meet growing stream sport-fishing needs is included at an estimated cost of $3,000,000 with an average of 173,000 annual user-days of benefits.

During this period, programs also would be provided for the enhancement of marine fish which would include the creation of additional production habitat through selective placement of rock jetties or submerged scrap automobiles. Shellfish production and harvest also would benefit from the construction of beach breakwaters where strong currents now limit the production. Studies and implementation of techniques to eliminate or control natural predators and the alteration of environment to promote and increase natural production are recommended. Shellfish and marine fish features have not been evaluated in terms of costs or benefits, but are included for further study by the State fish and game agencies.

The important ecology of the Snohomish River estuary would be protected by controlling development with provisions made for leaving some lands and marsh areas in their natural state. Development of the delta to provide the necessary sites for future water transport-oriented industrial development, as discussed under Navigation, is planned so as to provide a balance between this economic need for the land resource and the natural beauty and intangible values inherent in the estuary with waterfowl and mammals using portions of the delta for habitat.

A study being performed under the Estuary Protection Act (PL90-454) will focus on whether any land or water area within an estuary should be acquired by the Secretary of the Interior or by a State agency, or whether such an area may be adequately protected through local, State or Federal laws or other methods without Federal land acquisition or administration. This Act provides for agreement between the Secretary of the Interior and the State agencies to manage, develop, and administer estuary areas and requires that all Federal agencies give consideration to estuaries, their natural resources, and their importance for industrial and commercial developments, when the agencies plan the use or development of water in related land resources. The Snohomish estuary is recommended for consideration as part of the overall study being performed under the Estuary Protection Act.

Wildlife measures included for early action are the acquisition and development of 600 acres of estuary environment on Ebey Island, acquisition and development of 600 acres of band-tailed pigeon habitat in the Pilchuck Basin, and acquisition and development of upland bird habitat for release and hunting of game-farm birds. These measures are estimated to cost $1,265,000 and would produce an estimated 21,000 user-days of hunting activity each year. An addition to an existing Basin game-bird farm to rear approximately 8,000 pheasants is called for at an estimated investment cost of $300,000, which will provide 8,000 user-days of increased hunting annually.

Implementation of cooperative programs with private land owners to insure habitat retention and hunting is planned together with development and continued wildlife population studies. An educational program is included to stress renewable aspects of the wildlife resource and value of proper utilization of the resource. The cost of these measures is estimated at $15,000.

The projects and programs for fish and wildlife preservation and enhancement are tabulated below:

Fish and Wildlife Projects and Programs, 1970 to 1980.

Projects.

(a) Construction of trapping facilities for truck and haul of salmon above Snoqualmie Falls.

(b) Construction of two spawning channels, one mile each in length.

(c) Acquisition and development of access to 13 lakes.

(d) Purchase one lake and enlarge two others.

(e) Construciton of a trout hatchery to stock lakes.

(f) Correct gravel compaction problems in streams.

(g) Construction of steelhead rearing ponds.

(h) Construction of trout hatchery to stock streams.

(i) Acquisition of 50 miles of stream bank access.

(j) Acquisition and development of salt water access area.

(k) Acquisition and development of 600 acres of estuarine habitat on Ebey Island.

(l) Acquisition and development of 640 acres of band-tailed pigeon habitat–Pilchuck River.

(m) Acquisition and development of upland bird habitat.

(n) Addition to existing game bird farm to rear 8,000 pheasants annually.

Programs

(a) Development of fish disease control program.

(b) Development of new fish toxicants.

(c) Development of lake fertilization technique.

(d) Development of cooperative programs with private landowners to insure habitat retention and hunter access.

(e) Development of compatible forest-wildlife management technique.

(f) Development of educational programs regarding value of wildlife.

(g) Perform x-sectional studies of streams for optimum and minimum low flow determination.

(h) Locate, survey, and mark boundaries of all State-owned 2nd class tidelands in the Basin. Take steps to reserve all such lands for public use except as required for specific circumstances.

(i) Perform an inventory of shellfish stocks and recreational use of tidelands.

Fish and Wildlife
Project and Program Costs[1]
1970 to 1980

		Average Annual			
		Costs			
Feature	Investment Costs ($1000)	Interest & Amortization ($1000)	O&M ($1000)	Total ($1000)	Benefits ($1000)
Projects	20,030	1,341	146	1,487	3,396
Programs	450[2]				305[3]
Total	$20,480				$3,701

[1] Includes allocated fishery enhancement costs from multiple-purpose storage projects.

[2] Cumulative program costs for the period.

[3] Some of program benefits included in with project benefits.

1980-2000—Fishery enhancement programs planned for this period include passage facilities on Olney Creek at an estimated cost of $35,000 and fish passage improvements on four tributary streams for a distance of 27 miles at an estimated cost of $367,000. These projects would provide additional spawning habitat for nearly 22,400 chinook and coho salmon. Habitat improvement on 24 streams, covering over 45 miles of streambed at a cost of $150,000, would benefit four species of salmon resulting in a production increase of nearly 38,000 fish. Two additional salmon hatcheries would be constructed during this period at an estimated cost of $1,020,000 each to increase production by an average of 102,000 coho salmon annually. The game fish and wildlife programs and projects implemented during the period prior to 1980 would be continued, together with a few new projects as required. A total investment cost of $12,993,500 is estimated for the game fish and wildlife to be implemented during this period.

Fish and Wildlife Projects & Programs 1980–2000

Project	Investment Costs
Construct fish passage on Olney Creek	35,000
Construct fish passage on 4 tributaries	367,000
Improve habitat on 24 streams	150,000
Clear channels on 2 streams	1,500
Construct 2 salmon hatcheries	2,040,000
Other projects for fish and game including access and parking facilities to all State owned beaches	9,700,000
Total	$12,293,500
Program	
Continuation of fish and wildlife programs including improvement of public beaches for clam culture.	$750,000

2000-2020—After the year 2000, four additional hatcheries are planned for construction within the Snohomish Basin to produce nearly 200,000 additional adult chinook and coho salmon at a cost of $4,080,000. Eighty acres of rearing facilities to provide nearly 100,000 more chinook and coho salmon also are included at a cost of $440,000, plus one mile of spawning channel providing an increase of 120,000 chum salmon at an initial investment cost of $700,000. A total investment cost of $13,750,000 is estimated for game-fish and wildlife programs and measures during this period. The fish and wildlife projects scheduled for implementation prior to 2020 are tabulated below:

Fish and Wildlife
Projects and Programs
2000–2020

Project	Investment Costs
Construct 4 hatcheries or equivalent	4,080,000
Develop 80 acres of rearing facilities	440,000
Develop 1 miles of spawning channel	700,000
Other projects for fish and game	13,000,000
Total	$18,220,000
Program	
Continuation of fish and wildlife programs	$750,000

COST—BENEFIT SUMMARY

The investment costs by resource feature are shown in Tables 7-20 and 7-21 for the Snohomish Basin with the costs distributed between Federal, State, local and private interests. Average annual costs and benefits also are shown for projects recommended for implementation prior to 1980. The investment costs include cumulative annual program costs for each of the three planning periods as shown in Table 7-20 and capital project costs as shown in Table 7-21. Interest and amortization costs are based on a 100-year economic life with appropriate allowances made for major replacements. An interest rate of 4-5/8 percent was used in the economic analysis. All measures proposed for early action are justified on the basis of tangible benefits. Benefits for M & I Water Supply and water quality improvement were assumed equal to annual charges.

Investment costs were allocated to the various features on the basis of available information including the technical appendices, multiple-purpose project studies, and experience at similar projects.

TABLE 7-20. Program investment costs,[1] Snohomish Basin ($1000)

Feature	Private	Government			Total
		Local	State	Federal	
			1970–1980		
Water Quality Control	486	486	1,003	425	2,400
Flood Control		38	11	6	55
Watershed Management	54,351	28,640	5,050	20,463	108,504
Fish and Wildlife			450		450
Subtotal	$ 54,837	$29,164	$ 6,514	$ 20,894	$111,409
			1980–2000		
Water Quality Control	920	920	480	192	2,512
Flood Control		70	20	10	100
Watershed Management	58,564	26,225	6,733	42,705	134,227
Fish and Wildlife			750		750
Subtotal	$ 59,484	$27,215	$ 7,983	$ 42,907	$137,589
			2000–2020		
Water Quality Control	284	284	600	232	1,400
Flood Control		70	20	10	100
Watershed Management	56,729	29,236	6,733	42,842	135,540
Fish and Wildlife			750		750
Subtotal	$ 57,013	$29,590	$ 8,103	$ 43,084	$137,790
Total	$171,334	$85,969	$22,600	$106,885	$386,788

[1] Cumulative annual program costs over the period.

TABLE 7-21. Project investment costs[1] and cost-benefit summary, Snohomish Basin ($1000)

Feature	Investment Costs					Annual Costs			Annual Benefits	
	Private	Government: Local	Government: State	Government: Federal	Total	Interest & Amortization[2]	Operation & Maintenance	Total	Total	Net
1970–1980										
M&I Water Supply	900	34,821	0	0	35,721	1,749	1,101	2,850	2,882	32
Irrigation	825	0	0	0	825	64	72	136	136	0
Water Quality Control	85,230	5,645	2,823	3,692	97,390	4,588	1,074	5,662	5,662	0
Navigation[3]	0	1,043	0	1,157	2,200	103	17	120	172	52
Power	0	0	0	32,845[5]	32,845[5]	1,556[5]	242[5]	1,798[5]	1,867[4]	69[4]
Flood Control	0	3,195	0	74,623	77,818	3,677	145	3,822	7,184	3,362
Watershed Mgmt.[6]	0	621	0	1,882	2,503	117	25	142	397	255
Recreation	12,180	24,104	12,180	49,078	97,542	4,511	1,641	6,152	7,980	1,828
Fish & Wildlife	0	0	8,797	10,140	18,937	1,343	146	1,489	3,374	1,885
Sub-Total	$ 99,135	$69,429	$23,800	$173,417	$365,781	$17,668	$4,463	$22,171	$29,654	$7,483
1980–2000										
M&I Water Supply	650	63,732	0	0	64,382					
Irrigation	527	0	0	0	527					
Water Quality Control	10,300	9,790	4,895	7,495	32,480					
Navigation[3]	0	2,309	0	5,387	7,696					
Flood Control	0	3,787	0	36,083	39,870					
Watershed Mgmt.[6]	0	3,051	0	9,336	12,387					
Recreation	13,900	20,850	13,900	20,850	69,500					
Fish & Wildlife	0	0	12,294	0	12,294					
Sub-Total	$25,377	$103,519	$31,089	$79,151	$239,136					
2000–2020										
M&I Water Supply	0	19,465	0	0	19,465					
Irrigation	175	0	0	0	175					
Water Quality Control	23,200	8,000	4,000	8,500	43,700					
Navigation[3]	0	0	0	0	0					
Flood Control	0	3,626	0	32,629	36,255					
Watershed Mgmt.[6]	0	25	0	75	100					
Recreation	24,640	36,960	24,640	36,960	123,200					
Fish & Wildlife	0	0	18,220	0	18,220					
Sub-Total	$48,015	$68,076	$46,860	$78,164	$241,115					
Total	$172,527	$241,024	$101,749	$330,732	$846,032					

1 Capital project costs.
2 Of initial investment and major replacement.
3 Costs and benefits for pleasure boating moorage facilities included with Recreation.
4 Power benefits, North Fork Snoqualmie project.
5 Allocated power costs, North Fork Snoqualmie project.
6 Installation of structural measures only.

SEQUENCE OF DEVELOPMENT

The projects and programs of the Comprehensive Plan are summarized in Table 7-22 by period. The project numbers identify features on Figure 7-3.

TABLE 7-22. Future projects and programs, Snohomish Basin

Projects Prior to 1980

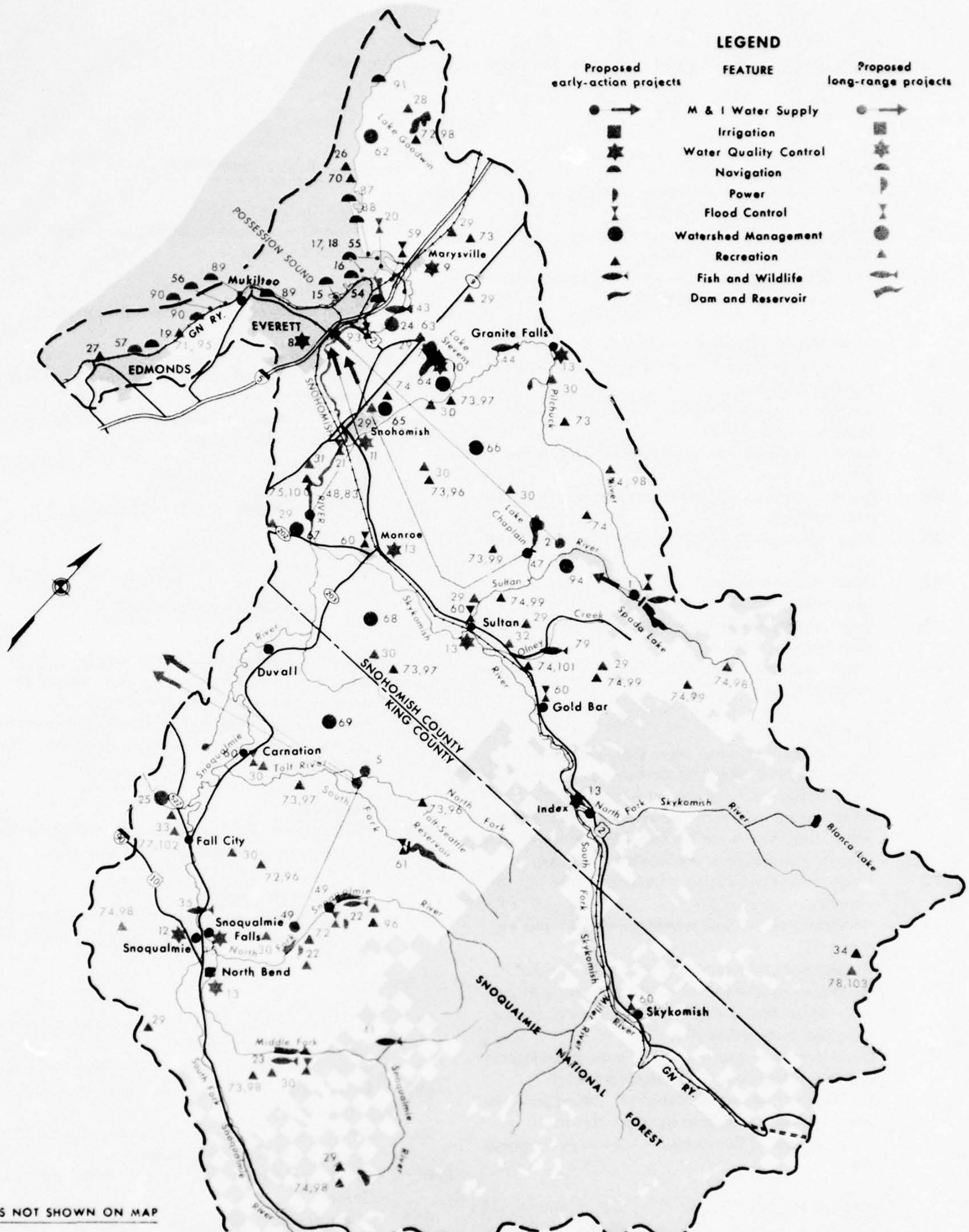
Project No.	
	Municipal and Industrial Water Supply
1.	Water supply storage for Everett—second stage of Sultan River multiple-purpose project (Culmback Dam).
2.	Improvement of water supply transmission system by constructing second tunnel between Sultan River and Lake Chaplain and installing additional pipelines—Everett.
3.*	Expansion of small and rural community municipal and industrial water supply and transmission systems.
4.*	Increase capacity of self-supplied industrial surface water system.
5.	Construction of diversion dam and transmission facilities on North Fork Tolt River—Seattle (for Cedar-Green Basins).
	Irrigation
6.*	Installation of individual farm irrigation pumping and sprinkler systems (private).
	Water Quality Control
7.	Installation of facilities to remove all settleable solids from mill effluents prior to discharge with adequate outfall and diffuser—pulp mills at Everett.
8.	Expansion of secondary treatment, disinfection, and sewage interception facilities at Everett.
9.	Expansion of disinfection facilities at Marysville.
10.	Installation of collection and treatment facilities at Lake Stevens.
11.	Expansion of secondary treatment and disinfection facilities at Snohomish.
12.	Installation of sewage interception at Snoqualmie.
13.	Installation of secondary treatment facilities; Monroe, Sultan, Index, North Bend, Snoqualmie Falls, and Granite Falls.
14.*	Improvement of waste collection facilities for recreation developments including small boat harbors.
	Navigation
15.	Channel improvement—East Waterway.
16.	Channel improvement—Snohomish River Mile 0.0 to Highway 99 bridge crossing.
17.	Dredge-fill of Tract Q and portions of Smith Island for terminal and water-transport-oriented industrial development.
18.	Small boat harbor development—Tract Q.
19.	Small boat harbor development—Meadowdale.
	Power
22.	Hydroelectric power installation—North Fork Snoqualmie multiple-purpose project.
	Flood Control
1.	Flood control storage—second stage of Sultan River multiple-purpose project.
20.	Modification of Snohomish River floodway at mouth of river.
21.	Setting back existing levees from River Mile 10.0 to River Mile 18.5 of Marsh Land and French Creek Drainage Districts.
22.	Flood control storage—North Fork Snoqualmie multiple-purpose project.
23.	Flood control storage—Middle Fork Snoqualmie multiple-purpose project.
	Watershed Management
24.	Small watershed multiple-purpose project—Snohomish River Estuary.
25.	Small watershed multiple-purpose project—Patterson Creek.
	Recreation
22.	Installation of recreation facilities as part of North Fork Snoqualmie multiple-purpose project.
23.	Installation of recreation facilities as part of Middle Fork Snoqualmie multiple-purpose project.
26.	Development of two recreation sites along saltwater shoreline from northern boundary of Basin to mouth of Snohomish River.
27.	Development of four recreation sites along saltwater shoreline from southern boundary of Basin to mouth of Snohomish River.
28.	Development of three recreation sites.
29.	Development of one recreation site.
30.	Development of two recreation sites.
31.	Development of three recreation sites along Snohomish River from mouth to confluence of Skykomish and Snoqualmie Rivers.

*Projects not shown on Figure 7-3.

TABLE 7-22. Future projects and programs, Snohomish Basin (Cont'd)

Project No.	
	Recreation (Cont'd)
32.	Development of three recreation sites along Skykomish River from mouth to National Forest.
33.	Development of four recreation sites along Snoqualmie River from mouth to National Forest.
34.	Development of 60 recreation sites in the National Forest.
	Fish and Wildlife
I.	Low flow augmentation and flood control—second stage construction of Sultan River multiple-purpose project.
22.	Low flow augmentation and flood control—North Fork Snoqualmie multiple-purpose storage project.
23.	Low flow augmentation and flood control—Middle Fork Snoqualmie multiple-purpose storage project.
35.	Construction of fish trapping facilities to collect and haul salmon above Snoqualmie Falls.
36.*	Construction of two spawning channels, each 1 mile in length.
37.*	Acquisition of 50 miles of streambank access, development of boat access at 13 lakes and enlargement of one lake.
38.*	Construction of trout hatchery for stocking lakes.
39.*	Correction of gravel compaction problems in streams.
40.*	Construction of steelhead trout rearing ponds.
41.	Correction of clay slides in Taylor and Snoqualmie Rivers.
42.*	Construction of trout hatchery for stocking streams.
43.	Acquisition and development of 600 acres of estuarine habitat on Ebey Island.
44.	Acquisition and development of 640 acres of band-tailed pigeon habitat in Pilchuck River drainage.
45.*	Acquisition and development of upland bird habitat.
46.*	Construction of addition to existing game farm to rear 8,000 pheasants annually.
	PROGRAMS PRIOR TO 1980
	Water Quality Control
a.	Establish and operate water quality surveillance stations at key salt and fresh water locations and prepare comprehensive sewerage plan for the Basin.
	Flood Control
b.	Establish and administer county-wide flood plain zoning measures under flood plain management program.
	Watershed Management
c.	Provide technical assistance and management for State and Federal lands.
d.	Provide technical assistance for on-farm and other private practices.
	Fish and Wildlife
e.	Develop lake fertilization techniques.
f.	Make wildlife population analysis and timberland management practices studies, develop habitat improvement techniques and an education program on proper game hunting concepts, and begin a program with land owners for game habitat retention and hunter access.
g.	Develop fish disease controls and new toxicants.
h.	Conduct cross-sectional stream surveys to determine minimum and ~~optimum streamflows~~ for fish.
i.	Locate, survey, and mark boundaries of all State-owned second class tidelands in the Basin. Take steps to reserve all such lands for public use except as required for specific circumstances.
j.	Perform an inventory of shellfish stocks and recreational use of tidelands.
	Projects 1980 to 2000
	Municipal and Industrial Water Supply
47.	Increase of transmission capacity of Everett water system.
48.	Construction of water supply pumping and treatment plant off Snohomish River—Everett.
49.	Increase storage capacity of North Fork Snoqualmie River project and install transmission lines—Seattle (for Cedar-Green Basins).
50.*	Installation of small and rural community municipal and industrial water supply transmission lines from Everett and Seattle systems.
51.*	Increase of capacity of self-supplied industrial surface water system.
	Irrigation
52.*	Construction of individual farm irrigation pumping and sprinkler systems (private).
	Water Quality Control
53.*	Expansion of waste treatment and interception facilities for municipalities, industry, and recreation development.
	Navigation
54.	Improvement of shallow draft channel—Highway 99 bridge to River Mile 10.0.
55.	Small boat harbor expansion—Tract Q.
56.	Small boat harbor development—Big Gulch.
57.	Small boat harbor development—Edmonds North.
58.*	Development of additional water transport-oriented industrial lands in the Snohomish River Delta.

*Projects not shown on Figure 7-3.



ITEMS NOT SHOWN ON MAP

- Rural and small community water supply projects
- Irrigable lands and private irrigation developments •
- Terminal and water transport oriented industrial lands •
- Small watershed boundaries •
- Scenic highway and potential recreation river segments
- Fish and wildlife projects yet to be sited

• See functional appendix for location maps

Scale in Miles

5 0 5 10

SNOHOMISH BASIN

FIGURE 7-3. Comprehensive Plan elements

TABLE 7-22. Future projects and programs, Snohomish Basin (Cont'd)

Project No.	
	Flood Control
59.	Improvement of floodway—Snohomish River, River Mile 3 to River Mile 6.3.
60.	Improvement of levee; Carnation, Gold Bar, Skykomish, Sultan and Monroe.
61.	Modification of outlet works for flood control storage—South Fork Tolt River.
	Watershed Management
62.	Small watershed multiple-purpose project—Tulalip-Warm Beach.
63.	Small watershed multiple-purpose project—Snohomish Estuary.
64.	Small watershed multiple-purpose project—Lake Stevens.
65.	Small watershed multiple-purpose project—Pilchuck River.
66.	Small watershed multiple-purpose project—Wood Creek.
67.	Small watershed multiple-purpose project—Cathcart area.
68.	Small watershed multiple-purpose project—Skykomish River.
69.	Small watershed multiple-purpose project—Snoqualmie River.
	Recreation
70.	Development of three recreation sites along saltwater shoreline from the northern boundary of the Basin to the mouth of the Snohomish River.
71.	Development of three recreation sites along saltwater shoreline from southern boundary to the Basin to the mouth of the Snohomish River.
72.	Development of three recreation sites in this vicinity.
73.	Development of two recreation sites in this vicinity.
74.	Development of one recreation site in this vicinity.
75.	Development of three recreation sites along Snohomish River from mouth to confluence of Skykomish and Snoqualmie Rivers.
76.	Development of four recreation sites along Skykomish River from mouth to National Forest.
77.	Development of five recreation sites along Snoqualmie River from mouth to National Forest.
78.	Development of 70 recreation sites in the National Forest.
	Fish and Wildlife.
79.	Construction of a fish passage facility on Olney Creek.
80.*	Construction of fish passage facilities or removal of obstructions on four tributaries.
81.*	Improvement of fish habitat on 24 streams.
82.*	Construction of two salmon hatcheries.

Project No.	
	PROGRAMS 1980 to 2000
	Water Quality Control
k.	Continue water quality, monitoring, evaluation and control programs.
	Flood Control
l.	Continue flood plain management program.
	Watershed Management
m.	Provide technical assistance for on-farm and other private practices.
n.	Provide technical assistance and management for State and Federal lands.
	Fish and Wildlife
p.	Continue fish and wildlife programs.
	PROJECTS 2000 to 2020
	Municipal and Industrial Water Supply
83.	Expansion of Snohomish River water supply pumping and treatment plant—Everett.
84.*	Installation of small and rural community municipal and industrial water supply transmission lines from Everett.
	Irrigation
85.*	Construction and expansion of individual farm irrigation pumping and sprinkler systems.
	Water Quality Control
86.*	Expansion of waste treatment and interception facilities for municipalities, industry, and recreation.
	Navigation
87.	Small boat harbor development—Tulalip Bay, First Phase and Second Phase.
88.	Small boat harbor development—Priest Point West.
89.	Small boat harbor development—Mukilteo and Mukilteo South.
90.	Small boat harbor development—Picnic Point North and Norma Beach North.
91.	Small boat harbor development—Port Susan-Warm Beach.
92.*	Development of additional water transport-oriented industrial lands in Snohomish River Delta.
	Flood Control
93.	Improvement of floodway—Snohomish River, River Mile 6.3 to River Mile 10.0.

*Projects not shown on Figure 7-3.

TABLE 7-22. Future projects and programs, Snohomish Basin (Cont'd)

Project No.	
	Watershed Management
94.	Small watershed multiple-purpose project–Sultan River.
	Recreation
95.	Development of one recreation site along saltwater shoreline from the southern boundary of the basin to the mouth of the Snohomish River.
96.	Development of four recreation sites in this vicinity.
97.	Development of three recreation sites in this vicinity.
98.	Development of two recreation sites in this vicinity.
99.	Development of one recreation site in this vicinity.
100.	Development of one recreation site along Snohomish River from mouth to confluence of Skykomish and Snoqualmie Rivers.
101.	Development of five recreation sites along Skykomish River from mouth to National Forest.
102.	Development of six recreation sites along Snoqualmie River from mouth to National Forest.
103.	Development of 100 recreation sites in the National Forest.
	Fish and Wildlife
104.*	Construction of four hatchery equivalent stations and development of 80 acres of rearing facilities and 1 mile of spawning channel.
	PROGRAMS 2000 to 2020
	Water Quality Control
q.	Continue water quality monitoring, evaluation and control programs.
	Flood Control
r.	Continue flood plain management program.
	Watershed Management
s.	Provide technical assistance for on-farm and other private practices.
t.	Provide technical assistance and management for State and Federal lands.
	Fish and Wildlife
u.	Continue fish and wildlife programs.

*Projects not shown on Figure 7-3.

PLAN ACCOMPLISHMENTS

The accomplishments of the Comprehensive Plan are shown in Table 7-23. All of the quantifiable needs of the Basin would be met by the Plan except for flood control to the extent desired, urban water management, and projected minimum flow requirements of the Snohomish River for water quality control in the year 2020. Nearly all urban areas would have 100-year flood protection by the year 2000 with construction of levees to supplement protection provided by the storage projects. However, about 300 to 500 acres of urban land in the lower Pilchuck River Basin above the town of Snohomish would not be provided 100-year protection and approximately 3,000 acres of rural land in the Skykomish River drainage below Gold Bar and above the mouth of the Sultan River would continue to be flooded at a frequency of once every three to five years. Rural areas located downstream near Monroe would receive some flood damage reduction from second stage construction of Culmback Dam with frequency of flooding in these areas reduced from the current average of once every three to five years to about once every 10 years. Flood plain zoning is relied upon in the Plan to control land use to the level of protection provided for the various portions of the flood plain.

All watershed management needs would be met except urban water management. These needs would be entirely met by the year 2000. In the preceding time period a residual is shown as intensive land use would be required to achieve a minimum density in order to facilitate project undertaking.

Minimum flows in the Snohomish River for most years would be higher than the 500 cfs (7 day low flow with reccurrence interval of once every 30 years) shown in Table 7-23 with the 890 cfs requested for 2020 expected to be generally available except during short periods occurring at the average rate of once every five years.

Recreation needs are assumed to be satisfied by including all the projects and programs called for in Appendix X, Recreation, for Snohomish Basin and construction of the Snoqualmie projects with public recreation sites and facilities. All of the rivers considered suitable for recreation status in Appendix

TABLE 7-23. Comprehensive Plan accomplishments, Snohomish Basin

Feature	Units	To 1980			To 2000			To 2020		
		Needs	Accomp.	Residual	Needs	Accomp.	Residual	Needs	Accomp.	Residual
M&I Water Supply	mgd	102.1	102.1	0	255.3	255.3	0	375.9	375.9	0
Irrigation	1000 Acre-Feet	12	12	0	19	19	0	22	22	0
Water Quality Control										
Waste	1000 Pop. Equiv.	5,429	5,429	0	5,722	5,722	0	5,700	5,700	0
Flow[1]	cfs	400	400	0	750	750	0	890	500	390
Navigation										
Commercial	1000 Short Tons	1,100	1,100	0	8,200	8,200	0	47,300	47,300	0
Pleasure Boats	Wet Moorages	4,056	3,130	926[3]	8,666	8,796	(130)[4]	17,656	23,676	(6,020)[4]
Power[2]										
Flood Control	$1000 Damage Reduction	3,520	2,240	1,280	6,370	5,180	1,190	13,100	11,679	1,421
Watershed Mgmt.										
Flood Prevention	1000 Acres	65.6	65.6	0	65.6	65.6	0	65.6	65.6	0
Watershed Prot. & Rehab.[5]	1000 Acres	1,194.6	1,194.6	0	1,194.6	1,194.6	0	1,194.6	1,194.6	0
Water Management[6]										
Agricult.	1000 Acres	25.7	25.7	0	42.9	42.9	0	57.2	57.2	0
Urban	1000 Acres	65.7	43.4	22.3	81.0	81.0	0	130.1	130.1	0
Recreation	1000 User-Days	5,200	5,200	0	12,000	12,000	0	24,000	24,000	0
Fish and Wildlife										
Sport										
Fishing	1000 User-Days	625	625	0	1,534	1,534	0	3,024	3,024	0
Hunting	1000 User-Days	93	93	0	212	212	0	284	284	0
Commerical Fishing	1000 Pounds	2,551	2,551	0	3,387	3,387	0	6,202	6,202	0

1 Snohomish River.

2 Power needs were projected for the Puget Sound Area only.

3 Residual wet moorage needs assumed to be satisfied by private developments.

4 Surplus wet moorages provided to satisfy spillover needs from Cedar-Green Basins.

5 The necessary level of management is assumed to be established throughout the Basin, otherwise some residual could occur.

6 Needs and accomplishments are cumulative.

X are left in their free-flowing state throughout their entire lengths except for the North and Middle Forks of the Snoqualmie River.

The sport and commercial fishery needs are assumed to be met by the projects contained in the Plan as the future consumptive withdrawals for M&I water supply and irrigation would not reduce the minimum stream flows during the critical summer season to less than those that have historically occurred. Future M&I withdrawals are generally planned for accomplishment by drawing water from storage during the summer season with a minimum flow to remain in the stream below the point of diversion. Where a diversion is planned the projects would be carried out in accordance with existing agreements with the Washington Departments of Fisheries and Game as is the case of the North Fork Tolt River project by the Seattle Water Department. Upon completion of detailed river studies to determine the required minimum and optimum flows for fish production, as called for during the early action period, adjustments may be made to the Plan. These adjustments could involve additional impoundments and adjustment to the operations of existing storage projects. During the critical summer seasons the streamflows immediately below the planned storage project would be at least equal to the historical lows. In most cases higher than historical minimum flows are provided as justified by fishery enhancement benefits.

The sport and commercial fishery needs would be satisfied by the Plan assuming that present pollution problems are corrected. As only specific solutions for the early action period were provided for wildlife needs, subsequent periods were assumed to be satisfied by projects and programs that will be developed later. A reduction in hunter success is anticipated with a willingness of hunters to accept a lower success ratio necessary in order to meet projected needs. Hunters also may be required to utilize hunting areas in Eastern Washington.

ALTERNATIVE ELEMENTS

Alternative measures considered to those elements contained in the Comprehensive Plan and reasons for not adopting these alternatives are discussed in this section.

Alternatives to Snoqualmie Storage Projects

A number of alternatives to the North and Middle Fork Projects were considered but rejected in favor of these projects. They include:

(1) Levee and channel improvements.—A combination of levees with upstream flood storage to provide 100-year flood protection for the towns of Snoqualmie and Snoqualmie Falls was not economically justified. A study of levees and channel improvements alone to protect farmlands along the Snoqualmie River below Snoqualmie Falls disclosed that the cost exceeded the flood control benefits; also, levees along the Snoqualmie River would remove floodwaters from valley storage, thereby increasing damages along the Snohomish River.

(2) Diversion.—Diversion of floodflows from the Snoqualmie River through the Sammamish River Basin to Puget Sound was considered. The cost of this alternative, however, was found to be greater than the benefits.

(3) Raising roads and highways.—Raising roads and highways to reduce flood damages also was found to lack economic justification.

(4) Flood plain evacuation.—Flood plain evacuation by purchase in fee would not be possible because of the magnitude of the existing improvements and facilities. A large percentage of the best agricultural land is located within the flood plain. Removal of this land from production would have a severe adverse impact on the agricultural economy of the Basin. The cost of relocating the urban communities or farm developments above the flood plain was found to exceed the cost of flood protection by other means. Furthermore, no practical method was found for implementing a plan for relocation which would be acceptable to residents in the valley.

(5) Single-purpose flood control storage.—All available impoundment sites in the Snoqualmie River watershed were evaluated on a flood control storage-only basis and found to lack economic justification for this single purpose.

(6) Flood plain management.—Land use zoning as an element of flood plain management can control future development of the Snoqualmie River valley and thereby limit flood damages. This measure would be an important part of any flood control program undertaken in the valley, but would not help in controlling flood damages to the existing developments.

(7) Uncontrolled development.—Exclusion of the Snoqualmie River projects from the Comprehensive Plan would result in flood damage reduction foregone in the magnitude of $941,000. Without the projects, average annual damage would be $2,700,000 or $941,000 more than the annual cost of $1,759,000 with the project under 1968 prices and conditions. A loss in needed water-related recreation opportunities also would occur if the projects were not constructed, as over 2,000 acres of water surface area would be available for boating, swimming, and fishing with their construction. Appendix X, Recreation, indicates a substantial requirement for additional water surface area after 1980 which can be met in part by these projects. The only hydroelectric power development found to be economically feasible within the Basin would not be available to meet the growing area power.

(8) Purchase of flowage easement.—This alternative would consist of retention of land at its present level of use by obtaining flowage easements. A flowage easement would involve the purchasing of the right to halt further developments within the flood plain. Farmers could develop their land on the basis of the current flood situation, restricting their activities to what would grow under present conditions. Similar restrictions would apply to all other economic activities and land use. A preliminary study of this alternative revealed that the total economic costs of flowage easements solutions would exceed the costs of the storage projects when opportunities foregone for electric power, fishery enhancement, water supply for municipal and industrial use and flood control and investments for recreation facilities to provide equivalent recreation opportunities are included. This alternative is not considered to be in consonance with existing public policy or good planning as an important existing problem, i.e., reoccurring flood damages is not mitigated.

Anadromous fish would not be directly affected by the structures since Snoqualmie Falls blocks all fish runs. However, augmentation of low flows from reservoir storage and reduction in peak flood flows would result in both sport and commercial salmon fisheries benefits that would be difficult to achieve by alternative means such as hatcheries and

spawning channels. The reservoirs also would provide greater trout fisheries in the project areas than now exist.

Alternatives to Second Stage Development of Culmback Dam, Sultan River

The Sultan River project is an existing development with modification by second stage construction being both feasible and economically justified to serve the water resource needs of municipal and industrial water supply, flood control, and fisheries. Satisfaction of the 1980 M & I water supply needs by alternative means such as other storage projects, use of ground water, direct river pumping and treatment, and desalinzation were briefly examined and determined to be far more costly than the existing project. Considerable investment has already been made for diversion and transmission facilities as part of the city of Everett's water supply system. A reduction in Everett's future service area, which includes the communities of Snohomish and Monroe that currently have their own sources of water, was considered. This alternative would consist of a number of smaller systems rather than a single, large purveyor; however, the economies of scale normally associated with a single, large water system together with possible adverse impacts on the environment due to a number of small surface water developments indicated that the alternative selected was in the best interest of the over-all well-being of the people residing in the Area and in the Basin.

A reduction in water supply demand through price adjustments was viewed as beyond the scope of study but certainly warranting consideration at the State and local level.

There are no feasible alternatives to the flood control and low flow augmentation for Sultan River anadromous and resident fish by this project.

Alternatives to Direct Diversion and Treatment of Snohomish River Water

By 1990, the Sultan River water resource on a firm flow basis will be at capacity use with a second source of supply required to meet the needs of the City of Everett and its service area. A multiple-purpose project on the North Fork of the Skykomish River was considered with municipal and industrial water supply and flood control benefits. A preliminary examination of the project for inclusion of power indicated that less than 10 MW could be derived with power added to a project justified on the basis of other benefits. Although the specific costs of power were not evaluated, power would probably not be a project purpose.

Preliminary operational studies were made of the North Fork Skykomish River Project for meeting Everett's needs to 2020. An average daily M & I Water supply of approximately 170 cfs was used in the operational studies with provision for 140,000 acres-feet of flood control storage from November through March and 20,000 acre-feet of water supply storage, with a full 160,000 acre-feet of conservation storage capacity available from May through September. These studies indicated that little flow augmentation for fish could be expected during late summer and early fall. The lack of low flow augmentation prevents the realization of fish enhancement benefits from the project. In addition, significant project costs for the mitigation of adverse impacts on the fish and wildlife resource of that Basin would be incurred. Fish losses have been tentatively evaluated at over $600,000 annually. Impacts on wildlife also would be significant by the North Fork project with an estimated reduction of 150 to 250 deer for an effective loss in hunting success yield of 45 to 75 deer annually, representing a reduction of 900 to 1,500 hunter-days. Small game losses tentatively have been evaluated at 500 hunter-days. Evaluated at $5 and $6 respectively per hunter-day, the total wildlife losses for the Skykomish project would fall in the range of $7,900 to $11,500 annually.

The cost of this project is estimated at approximately $145,000,000 with an additional $60,000,000 required for water supply transmission lines to the city's distribution works. Assuming an allocation of 25 percent of the storage project costs for M & I water supply, a total investment in the range of $96,000,000 would be required for water supply obtained by this alternative as compared to about $47,000,000 estimated for pumping and treatment plant, with transmission lines, constructed in two stages. Based on preliminary studies, the treatment plant was found to be the least cost alternative for meeting Everett's needs after capacity use of the Sultan River system has been achieved.

Other alternatives considered for meeting Everett's water supply needs included desalinzation, pumping ground water, and interbasin transfer with water diverted from the Stillaguamish River Basin.

Costs associated with desalinization are decreasing with improved technology but in most instances use of desalinzation facilities are economically fea-

sible only in situations where the nearest potable water supply is a considerable distance away. Detailed analysis would be required to determine if this solution is a favorable one when compared with other possible alternatives. The Key West Desalting Plant (2.62 mgd) operating at Key West, Florida, might be used for determination of cost estimates. This plant utilizes the multiple-stage flash evaportion process to deliver desalted water at approximately $.85 per thousand gallons with fuel oil as a source of energy. The U.S. Atomic Energy Commission predicts costs as low as $.19 per thousand gallons for the integrated nuclear power desalting plants by 1980. Costs of this order will be realized only in the extremely large plants producing 500 to 800 mgd. These costs are much higher than the low rate costs of water from the proposed Snohomish River pumping and treatment plant, which are estimated at $.10 to $.15 per thousand gallons.

The ground-water resource in the Snohomish River Basin has been estimated to be replenished at a rate of about 80,000 acre-feet annually or approximately 70,000,000 gallons per day. This resource is not considered adequate to meet the needs of a large water purveyor like the city of Everett.

A storage project on the South Fork of the Stillaguamish River was considered as an alternative source of future water supply for the city of Everett. This project was given a cursory study on the basis of multiple uses of flood control, irrigation, municipal and industrial water supply, and power. A multiple-purpose storage project located at the Robe site (see Stillaguamish Basin) with approximately 60,000 acre-feet of water supply storage could provide water in the amount of at least 170 cfs on a firm flow basis. However, a reduction in the minimum stream flows could adversely affect the existing and potential resident and anadromous populations. Since only preliminary study was given to this project, further investigations would be needed to determine economic feasibility, exact impacts on the fish and wildlife resource in the Stillaguamish Basin, and the project operation that would provide the maximum net benefits.

Other Flood Control Structures Considered

Additional flood control protection and flood damage reduction could be achieved by the construction of storage projects on the North Fork Skykomish, Miller and Beckler Rivers for rural areas lying in the Skykomish flood plain and on the Pilchuck River for rural areas on that stream's flood plain. A storage project on the North Fork of the Skykomish River with provision for flood control was discussed previously as an alternative source of municipal and industrial water supply for Everett. All of these projects would benefit the Snohomish River flood plain. The storage project located on the Miller River, tributary to the South Fork Skykomish, at approximately River Mile 0.6 could provide a peak discharge reduction of 5,000 cfs at the Snohomish gauge with a flood recurrence interval reduction of only one or two years. The storage project on the Beckler River, also a tributary to the South Fork Skykomish River, would provide an additional 6,000 cfs peak flood reduction of the Snohomish gauge. The combined effects of these projects would increase the flood protection provided by the Comprehensive Plan for the Marshland and French Creek agricultural areas from 25 years to approximately 30 years. Additional flood protection or flood damage reduction would be provided from these projects in the towns of Gold Bar, Sultan, Monroe, and Snohomish; the levees proposed for construction after 1980 for these communities would meet the flood protection objectives for urban areas.

Mitigation measures would be required to insure protection of anadromous fish runs in these rivers and the wildlife resource. Fish collection and downstream passage facilities would be necessary at the projects to insure adult salmon and steelhead access to spawning grounds above the dams and means by which fingerlings and smolts can migrate to the sea. The Miller Dam would provide 45,000 acre-feet of storage and be approximately 230 feet high and the Beckler Dam would provide 70,000 acre-feet of storage and be about 220 feet high. The projects also were considered as multiple-purpose projects with conservation pools being available to provide low-flow augmentation for the Skykomish River fish populations. However, the mitigation cost associated with the fish and wildlife resource impacted upon by the projects would probably exceed the enhancement benefits derived from the low flow augmentation.

The combined cost of these projects estimated at approximately $92,000,000 would not be justified prior to 1980 and with the implementation of flood plain zoning the additional flood damage reduction derived from these projects operated on a single-purpose basis would appear to be marginal even late in the 50-year study period. Accordingly, these

projects have not been included in the Comprehensive Plan. Future developments in the Skykomish and Snohomish flood plains with increasing property values may at some future date provide sufficient justification for construction of the Beckler and Miller River projects.

A storage project on the Pilchuck River at River Mile 22 with approximately 15,000 acre-feet of storage for flood control would provide flood control benefits to portions of the urban area developing along the lower Pilchuck River in the area of Snohomish and would have some relatively minor effect in reducing the level of flood damages in the Snohomish River flood plain. This project could be formulated on the basis of flood control, power, and municipal and industrial water supply for the city of Snohomish. The Comprehensive Plan provides for meeting the future growth in water supply needs of the community of Snohomish by purchase of water from the Everett system. With a requirement for a water treatment plant as an appurtenant facility to the storage project, the cost of water from this source for the community of Snohomish is viewed as being more expensive than water purchased from the city of Everett. A project could be formulated on the Pilchuck River for the purposes of power and flood control only; nevertheless, compatibility of a power and flood control development on the Pilchuck River is questionable from an economic standpoint. Although only preliminary consideration has been given to formulation of a multipe-purpose power project on this river, the preliminary studies that have been made indicate that neither a multiple-purpose project or a single-purpose project would be economically justified prior to 1980 with future justification also being questionable. Also, adverse impacts from the project could result in the fish resource in that shown.

The Pilchuck River near Granite Falls has an average annual run-off of approximately 250 cfs with the 7-day low flow of 30 cfs recurring about once in every ten years and about 24 cfs in thirty years. Although the water resource of the Pilchuck River is considered adequate to meet the present and projected needs for the city of Snohomish, it is not considered adequate to meet the present and projected needs for the city of Everett. A flood control storage project on the Pilchuck River has been estimated at $15,700,000; based on a 100-year project life, flood damage reduction in the amount of nearly $800,000 per year would be required to justify this project using a 4 5/8 percent interest rate. This required reduction exceeds total current average annual damages of $600,000 for the entire Skykomish Basin and equals 80 percent of that occurring in the Snohomish subbasin.

Preliminary studies indicate that the storage projects on the Beckler, Miller, North Fork Skykomish, and the Pilchuck Rivers may not be justified by the year 2020 if flood plain zoning is implemented to constrain future development in the flood plain and allow retention of open space and greenbelts. Uncontrolled intensive development in the flood plain, however, could warrant future consideration of these projects. Considerable recreation benefits also may accrue to these projects in the future if water-oriented recreational needs of the Basin cannot be met by other means, although a reduction in anadromous fish habitat could offset these benefits.

The foregoing storage projects could conflict with ecological and environmental objectives which are to retain rivers where possible in a natural free-flowing state. This factor was the overriding reason for excluding these projects from the long-range portion of the Plan at this time.

Alternatives to Recreation and Fish and Wildlife Measures

As limited information was provided with regard to specific locations of recreation developments, no analysis could be made to determine if sites and proposed developments selected were necessarily the most economical that could be provided to achieve a given amount of recreation benefits. All fish and wildlife measures contained in Appendix XI, Fish and Wildlife, were found to be compatible with the Comprehensive Plan at least those projects and programs recommended for implementation prior to 1980. Similarly, all fish and wildlife measures proposed after 1980 were included in the Comprehensive Plan with the exception of recommendations for flood control on 9 streams and low-flow augmentation on 5 other streams recommended for action between 1980 and 2000. Flood control and low flow augmentation were recommended for implementation by multiple-purpose projects on the following streams in Appendix XI, Fish and Wildlife:

Flood Control

Source	Length (miles)
Tolt River	8
Raging River	11
Tokul Creek	2
Skykomish River	28
Sultan River	8
Proctor Creek	2
Anderson Creek	2
North Fork of the Skykomish River	15
Beckler River	9

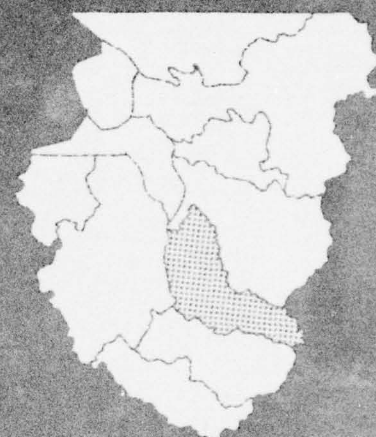
Flow Augmentation

Source	Length (miles)
Raging River	11
Elwell Creek	3
Sultan River	8
Wallace River	7
South Fork of the Skykomish River	20

With adoption of the Comprehensive Plan, the Sultan River, one of the above-named streams, would have flood control and low flow augmentation by 1980. This would result from second stage development of Culmback Dam. A certain amount of flood control affecting fish would be available by the year 2000 on the South Fork of the Tolt River, downstream from the City of Seattle water supply reservoir, as a result of the modification of the reservoir outlet works. As no flows were specified in Appendix XI, Fish and Wildlife, for low-flow augmentation or the level of flood control required in order to obtain a given level of fish benefits, the storage projects on the rivers tabulated above were not investigated. Completion of the cross-sectional study surveys by 1980 would provide data from which further studies can be undertaken to determine if these projects are justified on the basis of flood damage reduction to both real property and fish propagation as well as low flow augmentation.

In lieu of the flood control and low-flow augmentation measures recommended on the above streams for the period 1980 to 2000, two additional salmon hatcheries have been planned during this period to meet the needs for salmon fish production in the Snohomish Basin. Preliminary examination of the benefits to be derived from the storage projects, as tabulated in Appendix XI, Fish and Wildlife, indicates that storage for the fish resource could not be justified for this purpose alone, and that multiple-purpose projects justified on the basis of other uses would be required to support the incremental gains to the resource. Numerous small storage projects on tributary streams located above the existing reaches of the rivers used by the present salmon runs are not considered to be capable of providing necessary flood control and low flow augmentation. However, further study should be given to these measures after 1980.

Cedar-Green Basins



CEDAR—GREEN BASINS

DESCRIPTION OF BASINS

GENERAL

The Cedar-Green Basins comprise an area of 1,098 square miles of land, 53 square miles of fresh water, and 69 square miles of salt water. The Basins, which are three distinct drainage systems, are located almost entirely in King County with about 10 percent of the land area contained within Snohomish County. The Cedar and Sammamish Rivers flow into Lake Washington, which in turn drains into Puget Sound by way of the Lake Washington Ship Canal and Hiram Chittenden Locks. The Green River, known as the Duwamish River for its lower 11 miles, enters Elliott Bay, an arm of Puget Sound. The Green River drains an area of 483 square miles, the Cedar River drains 188 square miles and the Sammamish River drains 240 square miles.

Of the eleven major basins in the Puget Sound Area, the Cedar-Green ranks seventh in runoff with an average of 2,200,000 acre-feet flowing into Puget Sound annually.

The orographic lifting of the moist maritime air on the windward slopes of the foothills and higher elevations of the Cascades results in an increase in annual precipitation from 35 inches near the Sound to 125 inches or more on the wettest slopes. Approximately 50 percent of the annual precipitation falls between October and January, with 75 percent of the annual fall occurring between October and March. As the more intense weather systems move inland, 3 to 5 inches of precipitation in 24 hours is not unusual on the foothills and higher slopes. Winter snowfall ranges from less than 20 inches near the Sound to 400 inches or more at the crest of the Cascades, with a heavy snowpack in the higher elevations.

Streamflow characteristics and other data relating to the hydrology of the Basins are discussed in detail in Appendix III, Hydrology and Natural Environment. The physiographic characteristics of the Cedar-Green Basins are described in detail in Appendix V, Water-Related Land Resources.

PRESENT SITUATION

Local Economy

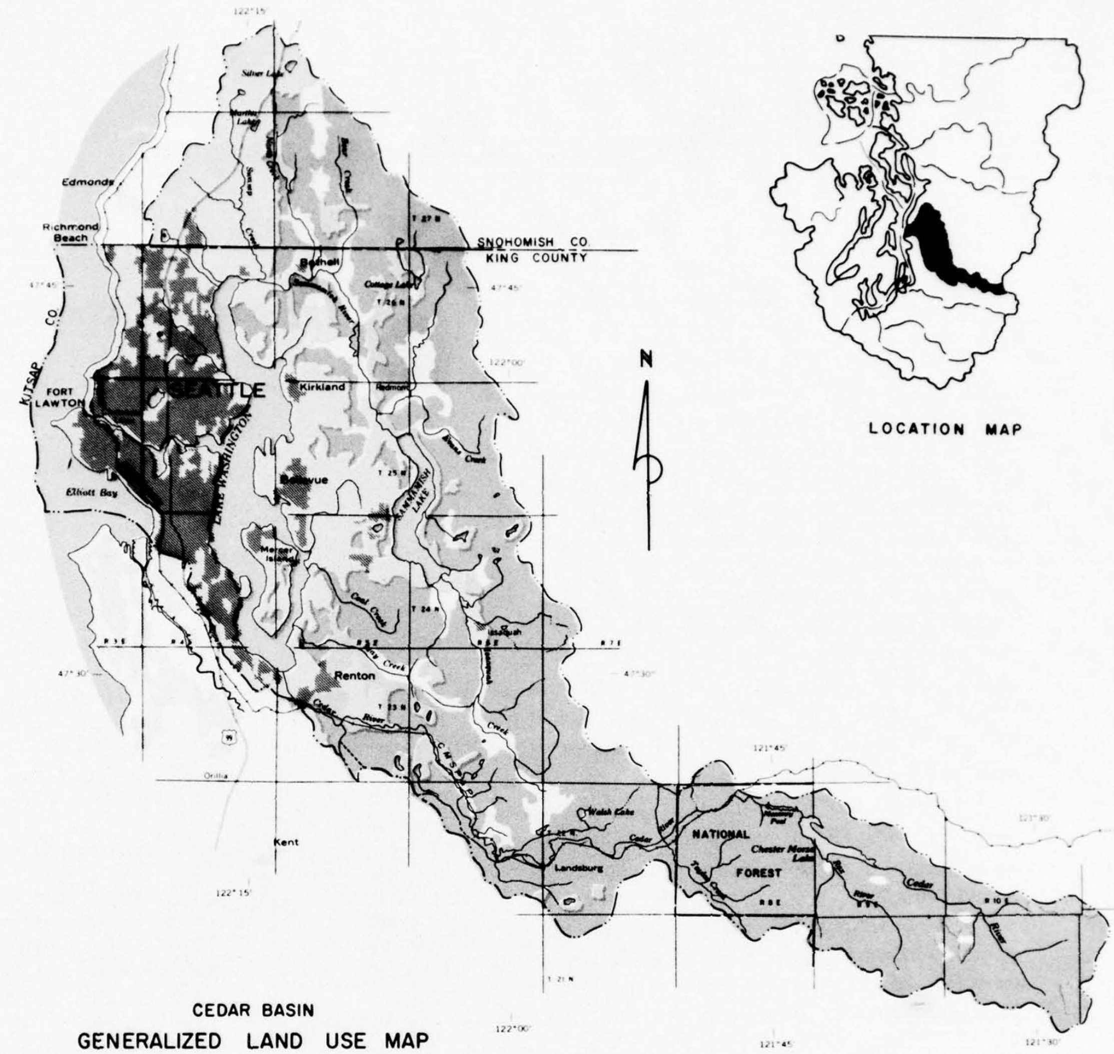
Approximately 1,100,000 people reside in the Basins. Seattle is the largest city in the Area, as well as the State, with a population in 1967 of approximately 580,000. The current population is more than half urban. Farmlands are rapidly being converted to residential, commercial and industrial use to accommodate the increasing population and industrial growth. Table 8-1 gives historical population statistics for the Basins and principal cities and towns.

TABLE 8-1. Historical population, Cedar-Green Basins

	1940	1950	1960	1967
Cedar-Green Basins	500,000	700,000	900,000	1,100,000
Principal cities and towns:				
Seattle	368,300	467,600	557,100	580,000
Renton	4,500	16,000	18,500	23,100
Bellevue	--	--	12,800	22,000
Auburn	4,200	6,500	11,900	17,100
Kent	2,600	3,300	9,000	14,000
Enumclaw	2,600	2,800	3,300	3,900
Redmond	500	600	1,400	6,100
Bothell	800	1,000	2,200	4,100
Issaquah	800	1,000	1,900	3,500

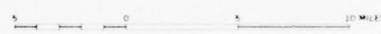
Source: Appendix IV, Economic Environment, Appendix V, Water-Related Land Resources.

The most important industry in the Basins is the transportation equipment industry. Other important industries include clay products, foundries, timber and related forest products, farming, mining, fisheries and various forms of manufacturing. Recreation, especially boating, swimming, water skiing and sport fishing, also contribute to the economy. Elliott Bay provides an excellent harbor of nearly unlimited depths. The modern terminal facilities and excellent



CEDAR BASIN

GENERALIZED LAND USE MAP



LEGEND

- BUILT-UP AREAS
- FOREST
- RURAL NON-FARM
- CROPLAND
- RANGE
- UNPRODUCTIVE FOREST LAND
- RESERVED PRODUCTIVE FOREST LAND
- GRASS, BRUSH, & BARRENS

FIGURE 8-1.

backup land transportation system enable the Port of Seattle to serve both foreign and domestic deep draft vessels and local shallow draft craft. Waterborne commerce continues to be a stimulus to the economy.

Land Use

Within the Cedar-Green Basins there is a total of 704,200 acres of land. The present use of this land is tabulated in Table 8-2 and shown on Figures 8-1 and 8-2.

TABLE 8-2. Present land use, Cedar-Green Basins

Land Use	Acres	Percent
Forest[1]	446,700	63.4
Range	3,400	0.4
Cropland	53,400	7.5
Rural non-farm	34,300	4.8
Intensive	166,400	23.9
Total	704,200	100.0

[1] Includes alpine and other non-forested lands normally associated with forest.

Source: Appendix V, Water-Related Land Resources.

Forests are the largest use of the land with 63% of the land in this category. Agricultural levels account for 7.5% of current land use and are largely located on the rich alluvial lowlands. More than 75% of this land is used to support the livestock industry.

The intensive use amounts to 24% of total land use, the greatest percentage for any of the basins in the Puget Sound Area. This category consists of residential, commercial, industrial, public and semi-public uses and reserved open space. Intensive land use (see Appendix V, Water-Related Land Resource) is distributed in acres as follows: railroads 3,000, roadways 9,000, airports 3,000, and urban (built-up) 152,000, for a total of about 167,000 acres.

The major areas of intensive development are along the shoreline of Puget Sound and Lake Washington and to the east and south of Seattle. Other incorporated communities are located throughout the Basins including Renton, Bellevue, Mercer Island, Kirkland, Bothell, Auburn, Kent, Redmond, Des Moines, Issaquah, Enumclaw, Houghton, Medina, and Tukwila. There are many smaller incorporated and unincorporated communities.

Land ownership distribution is shown in Table 8-3.

TABLE 8-3. Land ownership, Cedar-Green Basins

Ownership	Percent
Private	53.2
Private Corporate	23.0
Federal	10.2
State	4.1
Local Government	9.5
Total	100.0

Source: Appendix V, Water-Related Land Resources.

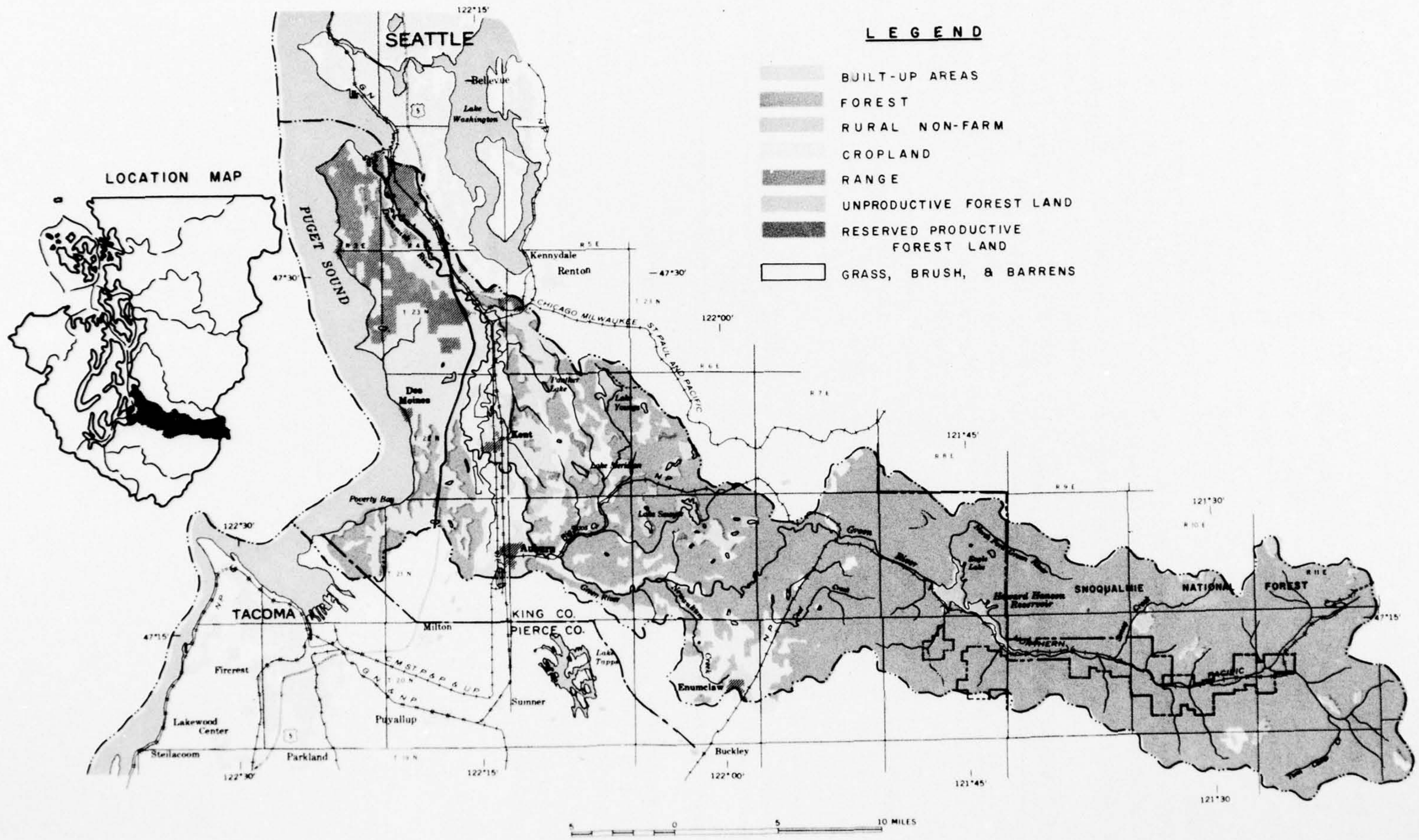


FIGURE 8-2.

GREEN BASIN
GENERALIZED LAND USE MAP

PROJECTED ECONOMY AND LAND USE

Local Economy

Tabulated in Table 8-4 is a forecast of population employment and gross regional product for the Central Division (Snohomish, King, Pierce, and Kitsap Counties) and projected population for the Cedar-Green Basins, with these forecasts translated into average annual growth trends. Agricultural and lumber and wood products employment in the Basins is expected to decline as croplands and forest areas are put to more intensive use.

TABLE 8-4. Economic projections, Cedar-Green Basins

	1963	1980	2000	2020	Average Annual Growth Trends (Percent) 1963 To 1980	1980 To 2000	2000 To 2020	1963 To 2020
Central Division								
Pop. (1000's)	1,603.0	2,418.9	3,882.1	6,235.5	2.4	2.4	2.4	2.4
Emp. (1000's)	579.1	873.2	1,399.8	2,248.4	2.4	2.4	2.4	2.4
G.R.P. (1,000,000's) (1963 $)	5,172.0	10,022.0	24,569.0	62,061.0	3.9	4.6	4.7	4.4
Cedar-Green Basins								
Pop. (1000's)	976.9	1,454.8	2,270.0	3,619.9	2.4	2.4	2.4	2.4

Source: Appendix IV, Economic Environment; Appendix V, Water-Related Land Resources.

Future Land Use

The projected land use of the Cedar-Green Basins for 2020, shown on Figures 8-3 and 8-4 is compared in Table 8-5 with present land use. This land use pattern is based on the construction of a cross-sound bridge and a bridge between the mainland and southern Whidbey Island. The Cedar-Green Basins are projected to have an intensive land use density increase from the present 5.9 persons per acre to 16.2 persons per acre by 2020.

To support an increase in population of 3.3 times the present population by 2020 there would be a need for about 56,500 acres of land to be converted from other uses to intensive use. Intensive land use would increase by 1.3 times its present amount. These lands would come primarily from present forest and agricultural lands. Forest lands would decrease by about 6 percent, range lands by about 15 percent, cropland by about 33 percent and rural non-farm by 38 percent. By the year 2020, the Cedar-Green Basins would be the center of a large metropolitan band stretching from north of Everett to south of Tacoma. Implementation of flood plain zoning would ensure that construction in the flood plain is compatible with the flood risk, and would aid in the retention of fertile lands for agricultural use and provide necessary open space and greenbelts.

TABLE 8-5. Present and projected[1] land use, Cedar-Green Basins (acres)[2]

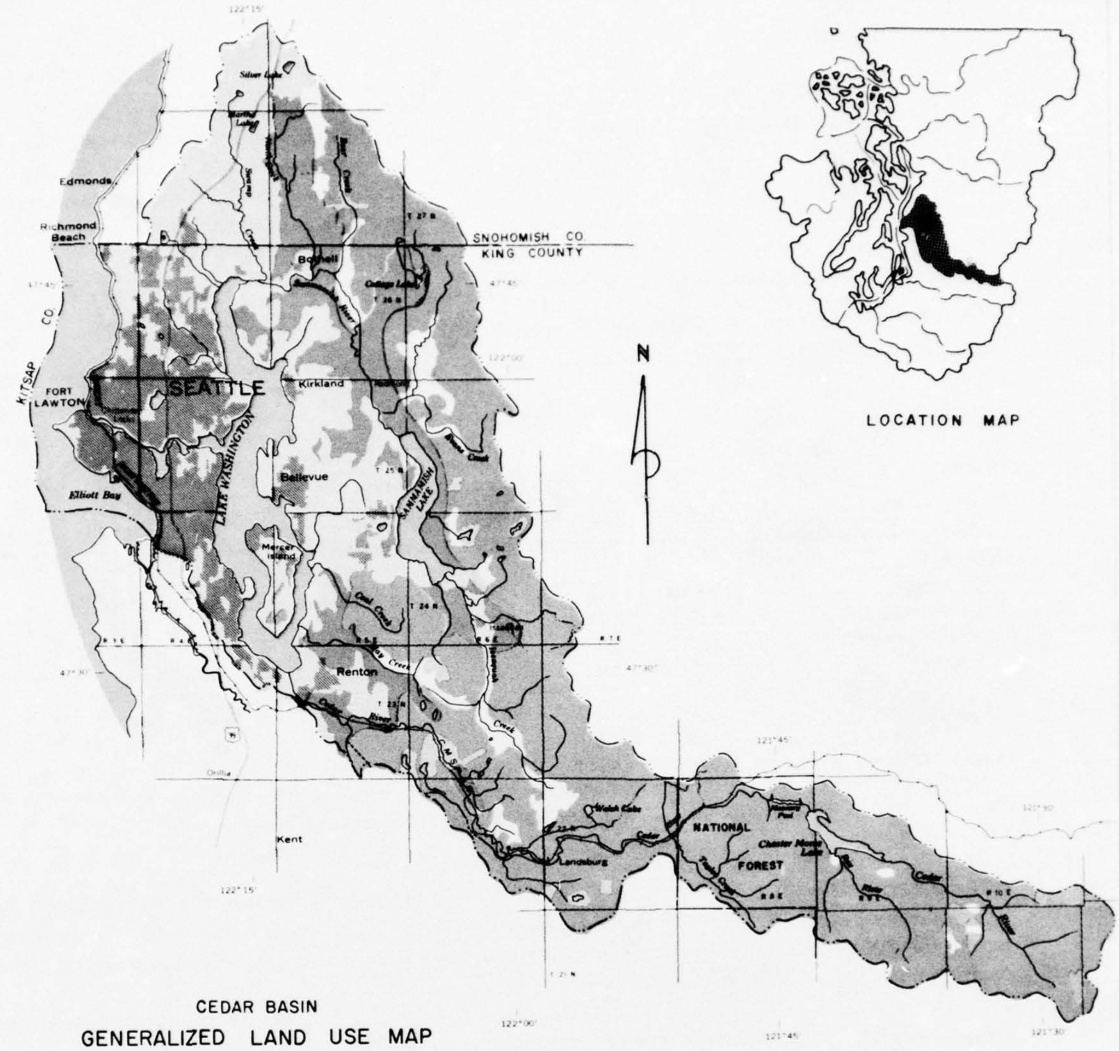
Land Use	1967	1980	2000	2020
Forest	446,700	442,000	435,000	421,400
Range	3,400	3,200	3,000	2,900
Cropland	53,400	51,000	46,000	35,800
Rural non-farm	34,300	28,000	23,000	21,200
Intensive	166,400	180,000	197,200	222,900
Total	704,200	704,200	704,200	704,200
Population	1,100,000	1,454,800	2,270,000	3,619,900
Density[3]	5.9	8.1	11.5	16.2

[1] Alternative Land Use Pattern C_2, see Puget Sound Area.

[2] Figures rounded to nearest hundred.

[3] Persons per intensive land use acre.

Source: Appendix V, Water-Related Land Resources.



CEDAR BASIN

GENERALIZED LAND USE MAP

Alternative C2 –2020

LEGEND

- PRESENT BUILT-UP AREAS
- BUILT-UP AREAS YEAR 2020
- FOREST
- RURAL NON-FARM
- CROPLAND
- RANGE
- UNPRODUCTIVE FOREST LAND
- RESERVED PRODUCTIVE FOREST LAND
- GRASS, BRUSH, & BARRENS

FIGURE 8-3.

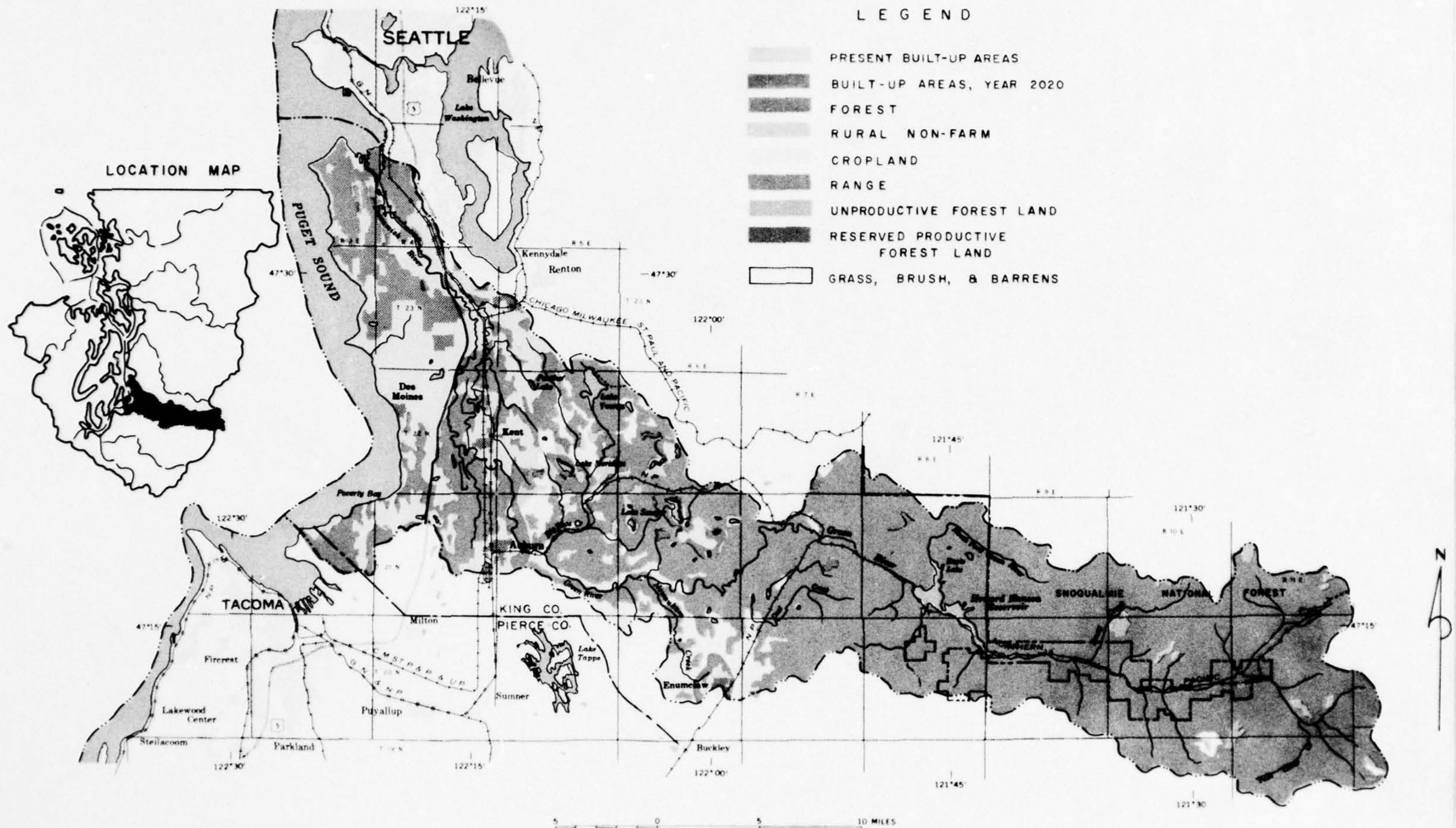


FIGURE 8-4.

GREEN BASIN
GENERALIZED LAND USE MAP
Alternative C2 -2020

WATER AND RELATED LAND RESOURCE NEEDS

MUNICIPAL AND INDUSTRIAL WATER SUPPLY

General

The city of Seattle, which supplies more than 85 percent of the total municipal water used in the Basins, obtains its water from two major sources. These sources are the Cedar River in the Cedar Basin and the South Fork of the Tolt River in the Snohomish Basin. A low crest diversion dam on the Cedar River is located near Landsburg. In the watershed about 15 miles above the diversion dam lies Chester Morse Lake, which has approximately 52,000 acre-feet of storage used for water supply and hydroelectric power generation. From Landsburg, water is piped 10 miles to Lake Youngs which acts as a settling basin and provides off-stream storage of 11,000 acre-feet. The large gravity transmission mains from the Cedar River can deliver 220 mgd.

The cities of Renton, Auburn and Kent derive their water supply from wells and/or springs. Water from the Everett municipal system is supplied to Mountlake Terrace through the Alderwood Water District. Numerous rural community systems supply ground water sources. Water is diverted from the Green River into the Puyallup Basin by the city of Tacoma to fulfill a portion of its system needs. The city of Tacoma's present and future inter-basin water transfer is viewed separately from the Cedar-Green Basins' requirements, but considered in determining the Basins' ability to satisfy their own needs.

Industry uses about 34 percent (57 mgd) of the total water consumed in the Basins. Several industries, generally in the Seattle area, use self-developed surface sources for non-consumptive purposes of cooling or gravel washing. The use of water in this "self-supplied" category is approximately 35 mgd.

The surface and ground water use is shown in Table 8-6.

TABLE 8-6. Municipal and industrial water use 1965, Cedar-Green Basins

System	Estimated Population served	Surface water usage (mgd) Average daily	Maximum monthly	Maximum daily	Ground water usage (mgd) Average daily	Maximum monthly	Maximum daily
MUNICIPAL USE							
Seattle[1]	887,420	91.90	130.00	253.00	--	--	--
Olympic View Water District	(13,500)	(1.20)	(2.36)	(3.00)	--	--	--
Edmonds	(8,200)	(0.50)	(0.75)	(1.00)	--	--	--
Kirkland	(10,000)	(0.85)	(1.02)	(1.20)	--	--	--
Bothell	(3,700)	(0.20)	(0.60)	(1.00)	--	--	--
Normandy Park	(1,640)	(0.12)	(0.24)	(0.37)	--	--	--
Tukwila	(1,600)	(0.23)	(0.25)	(0.27)	--	--	--
Duvall	(525)	(0.03)	(0.06)	(0.10)	--	--	--
Renton	38,175	--	--	--	4.10	6.30	8.50
Mountlake Terrace	(13,400)	(0.80)	(1.20)	(3.20)	--	--	--
Auburn	17,100	1.90	2.60	3.25	1.10	1.40	1.75
Kent	10,457	--	--	--	2.47	2.81	3.15
Enumclaw	8,500	--	--	--	0.90	1.30	1.70
Redmond	3,497	--	--	--	0.33	0.97	1.60
Issaquah	2,368	--	--	--	0.35	0.43	0.50
Pacific	1,668	--	--	--	0.20	0.25	0.30
Black Diamond	1,035	--	--	--	0.18	0.22	0.25
Other rural community systems	55,000	0.08	0.20	0.28	4.12	7.53	11.30
Subtotal	1,025,220	93.90	132.80	256.50	13.80	21.20	29.10
RURAL–INDIVIDUAL USE	15,000	0.10	0.10	0.20	0.80	1.00	1.40
INDUSTRIAL USE							
Municipally Supplied:							
Seattle:							
Food and kindred		3.82	4.00	4.27	--	--	--
Chemicals, metals, oils		9.20	10.30	12.21	--	--	--
Lumber and wood		1.31	1.60	1.80	--	--	--
Stone, clay, glass		0.03	0.03	0.04	--	--	--
Transportation		5.01	5.94	6.82	--	--	--
Renton:							
Food and kindred		0.01	0.01	0.01	0.01	0.02	0.03
Transportation		--	--	--	1.05	1.05	1.15
Kent:							
Food and kindred		--	--	--	0.13	0.26	0.39
Chemicals, metals, oils		--	--	--	0.25	0.28	0.30
Auburn:							
Food and kindred		0.02	0.02	0.03	0.01	0.01	0.02
Transportation		0.10	0.11	0.13	0.05	0.06	0.07
Self-supplied:							
Food and kindred		--	--	--	0.30	0.32	0.34
Chemicals, metals, oils		31.00	34.00	37.00	--	--	--
Lumber and wood		3.34	4.26	5.27	0.12	0.17	0.22
Stone, clay, glass		0.53	0.58	0.64	0.42	0.56	0.72
Subtotal		54.40	60.90	68.20	2.30	2.70	3.20
Total	1,040,220	148.40	193.80	325.00	17.00	25.00	33.70

[1] Includes Bellevue.

Source: Appendix VI, Municipal and Industrial Water Supply.

Present and Future Needs

Existing surface and ground water supplies are adequate to meet current municipal and industrial needs. Projected growth in population and industrial development within the Cedar-Green Basins would correspondingly increase municipal and industrial water needs. These needs are projected to rise from the 1965 level of about 165 mgd to 1,122 mgd in 2020. Shown in Table 8-7 are the projected water requirements in the Basin.

TABLE 8-7. Projected municipal and industrial water needs, Cedar-Green Basins

Year	Use	Total (Avg. Daily M.G.D.)	Total (1000 A.F. annually)	M.G.D.	Net Needs[1] (1000 Acre-Feet)
1965	Municipal	107.7	120.6		
	Industrial	56.7	63.5		
	Rural-Individual	0.9	1.0		
	Total	165.3	185.1		
1980	Municipal	257.9	288.8		
	Industrial	94.5	105.8		
	Rural-Individual	1.2	1.3		
	Total	353.6	395.9	188.3	210.8
2000	Municipal	354.0	396.5		
	Industrial	227.7	255.0		
	Rural-Individual	2.1	2.4		
	Total	583.8	653.9	418.5	468.8
2020	Municipal	559.0	626.1		
	Industrial	560.1	627.3		
	Rural-Individual	3.3	3.7		
	Total	1,122.4	1,257.1	957.1	1,072.0

[1] Cumulative total above 1965 use.

Source: Appendix VI, Municipal & Industrial Water Supply.

IRRIGATION

General

The Basins contain about 13,990 acres of potentially irrigable land of which 2,640 acres are now irrigated. The irrigated lands are located in the lower reaches of the Cedar and Green Rivers and in the Sammamish River Valley. These areas are changing from farming to urban areas and the irrigated acreage can be expected to decrease in the future. About 1,100 acres on the alluvial flood plain of the upper Green River Valley are the only lands expected to be irrigated by the year 2020. Eighty percent of the irrigation water is supplied from surface sources with total current annual diversions amounting to 5,600 acre-feet per year.

Present and Future Needs

Irrigation has been steadily decreasing due to the rapid expansion of housing and industry into irrigated areas. Existing irrigated lands are expected to decrease from the current 2,600 acres to 1,100 acres by the year 2020. Eight-hundred acres of lands along the Green River, above Auburn, are projected to be placed under irrigation. This, together with about 300 acres of land now irrigated in the Green River Valley, would be the total land irrigated by 2020. With few exceptions, the quality and quantity of the waters in the Basins are adequate to meet present irrigation needs although local problems may be experienced with ground water near the highly urbanized areas.

The projected irrigation needs are presented in Table 8-8.

TABLE 8-8. Irrigation present status and projected needs, Cedar-Green Basins

Year	New Irrigation (acres)	Total Irrigation (acres)	Total Annual Diversion (ac. ft.)	Net Needs[2] (ac. ft.)
1966	--	2,600	5,600	--
1980	--	1,800	3,900	--
2000	400	900	1,900	1,000[1]
2020	400	1,100	2,400	2,000[1]

[1] New irrigation.

[2] Cumulative annual diversion above 1966 use.

Source: Appendix VII, Irrigation.

The monthly distribution of the irrigation requirements are shown below as percent of annual demand:

May	7%	July	33%	September	14%
June	20%	August	29%	Total	100%

WATER QUALITY CONTROL

General

The chemical quality of most streams and lakes is soft, low in dissolved solids, and high in dissolved oxygen concentrations. The greatest concentrations of dissolved solids occur in the Lake Washington Ship Canal. Ground waters contain dissolved solid concentrations of less than 200 mg/l in the shallower aquifers. Brackish water occurs only locally in the deeper aquifers. The dissolved oxygen concentrations indicate that most fresh waters contain adequate amounts of dissolved oxygen for the maintenance of aquatic life. The Duwamish River, downstream from Tukwila, is a stratified estuary. Stream temperatures have reached maximums of 75.6°F for the Green River at Auburn and 73.0°F for the Cedar at Renton. Streamborne sediment is not a serious problem in the upper parts of the rivers. A dense cover of vegetation on most slopes largely precludes excessive soil erosion. Turbidity has run high in Issaquah Creek with a recorded maximum of 350 JTU. The Sammamish River at Bothell and the Duwamish River at Tukwila also have occurrences of high turbidity.

The daily wasteload generated in the Cedar-Green Basins approximates 839,000 population equivalents, of which 44 percent is presently removed by treatment before being discharged to fresh and marine waters. Municipalities and industries were discharging approximately 495,000 PE of wastes daily into Elliott Bay and Puget Sound in 1965 with twenty-seven percent of this wasteload released untreated. The 1965 waste generation, treatment, and discharges are summarized in Table 8-9.

Present and Future Needs

State-Federal water quality standards provide the baseline from which present and future needs for water quality control are determined. The water quality classifications established by the State for each watercourse in the Basins are outlined in Appendix XIII, Water Quality Control.

The water quality of Lake Washington has shown substantial improvement since the establishment and implementation of an area-wide sewerage plan. Except for storm overflows, municipal and industrial waste discharges have been removed from the lake. Projected use of the ship canal and locks connecting the Lake with Puget Sound, together with planned increase in municipal and industrial water diversion from the Cedar River may create problems in keeping salt water from intruding into Lake Washington.

A raw wasteload of 2,359,000 PE is projected by 1980 with municipal waste production expected to account for about 77 percent of this total.

TABLE 8-9. Summary of municipal and industrial wastes, Cedar-Green Basins, 1965

Receiving Water	Estimated Population Served	Nonseasonal Untreated Waste PE	Seasonal Untreated Waste PE	Treatment	Nonseasonal Waste Discharge PE	Seasonal Waste Discharge PE
Puget Sound						
Richmond Beach STP	15,000	16,300	--	Primary	4,400	--
Highlands SD	300	350	--	None	350	--
Carkeek Park STP	25,000	31,000	--	Primary	15,500	--
West Point STP	180,000	228,000	--	Primary	113,000	--
Alki Point STP	35,000	37,000	--	Primary	21,000	--
S.W. Suburban STP (Salmon Cr.)	24,000	30,000	--	Primary	24,000	--
S.W. Suburban STP (Miller Cr.)	4,000	5,000	--	Primary	3,500	--
Seattle-Tacoma Airport	1,000	1,000	--	Secondary	300	--
Des Moines SD	1,350	1,500	--	Primary	1,000	--
Salt Water St. Park	--	1,000	3,000	Primary	600	1,800
Sylvia Pines SD	1,200	1,400	--	Primary	840	--
Lake Haven SD, STP	5,000	6,000	--	Primary	4,000	--
Lake Sammamish						
Issaquah Creek						
Issaquah	6,000	8,700	--	Secondary	640	--
Food processing		1,600	--	Secondary	320	--
Elliott Bay						
Food processing	--	136,000	--	None	136,000	--
Lumber & wood	--	500	--	None	500	--
Green River						
Newaukum Creek						
Food processing	--	22,000	--	Primary	20,000	--
Auburn Academy	700	1,000	--	Primary	700	--
Big Soos Creek						
Black Diamond	1,026	1,200	--	None	1,200	--
Auburn	17,100	25,000	--	Lagoon	5,000	--
Food processing	--	16,000	--	Primary	14,000	--
Kent	13,000	14,600	--	Secondary	7,270	--
Food processing	--	--	51,000	Kent	--	25,000
Kent North Lagoon	--	37,000	--	Secondary	3,500	--
Food processing	--	(22,000)	--	Kent N. Lagoon	(3,000)	--
Duwamish River						
Food processing	--	46,000	4,000	None	46,000	4,000
Chemicals	--	11,000	--	None	11,000	--
Metals	--	2,400	--	None	2,400	--
Renton STP	8,000	93,000	--	Secondary	4,250	--
Tukwila STP	9,000	10,000	--	Secondary	2,400	--
Rainier Vista SD	3,000	3,500	--	Secondary	1,200	--
Diagonal Way STP	45,000	51,000	--	Primary	25,400	--
Total	467,000	839,000	58,000	--	470,000	30,800
Municipal	--	582,000	3,000	--	236,000	1,800
Industrial	--	257,000	55,000	--	234,000	29,000

Source: Appendix XIII, Water Quality Control.

The present and projected wasteloads are as shown in Table 8-10.

TABLE 8-10. Present and projected raw wasteloadings, Cedar-Green Basins (1000's PE)

Year	Municipal	Industrial	Recreational	Total	Net Needs[1]
1965	1,000	299	49	1,348	776
1980	1,827	454	78	2,359	1,787
2000	2,940	897	149	3,986	3,414
2020	4,739	1,645	274	6,658	6,086

[1] Cumulative raw wasteload requiring treatment above that receiving treatment in 1965.

Source: Appendix XIII, Water Quality Control.

NAVIGATION

General

Seattle is the major port in the Puget Sound Area. The port includes an outer salt water harbor and an inner fresh water harbor. The outer harbor consists of Elliott Bay, Shilshole Bay, the East, West, and Duwamish Waterways, and portions of the remaining marine shoreline. The inner harbor consists of Lakes Washington and Union, which are joined with each other and Puget Sound by the Lake Washington Ship Canal, and the "Hiram M. Chittenden" navigation locks. The harbor accommodates craft transporting general cargo, bulk grain, forest products, bulk petroleum, and dry and liquid bulk in foreign import and export as well as in coastwise traffic. Marine terminals and the water transport-oriented industry occupied approximately 2,800 acres of land in 1963 with development primarily concentrated along the shoreline of Elliott Bay, the Duwamish River and at the south end of Lake Washington at Renton.

Many small boat harbors are located in the Cedar-Green Basins with about 5,700 wet moorages available to the public in 1966.

Present and Future Needs

The major navigation needs in the Cedar-Green Basins included maintaining the water levels in Lakes Union and Washington during low runoff years within specified ranges, and channel deepening in the Duwamish River Waterways to accommodate increasing vessel drafts of freighters and bulk carriers.

Further small boat harbor development would be necessary to meet current and future moorage needs. Existing and projected waterborne commerce and wet moorage needs are shown in Table 8-11.

TABLE 8-11. Projected pleasure boating needs and waterborne commerce, Cedar-Green Basins

	Small Boat Wet Moorages			Waterborne Commerce (1000's Short Tons)	
Year	Total	Net Needs[1]	Year	Total	Net Needs[2]
1966	6,710	1,010	1963	12,800	--
1980	10,920	5,220	1980	22,000	9,200
2000	21,200	15,500	2000	32,600	19,800
2020	41,200	35,500	2020	50,000	37,200

[1] Cumulative needs above the wet moorage available in 1966.

[2] Cumulative waterborne commerce above total for 1963.

Source: Appendix VIII, Navigation.

Additional terminal and water transport-oriented industrial lands would be required to accommodate the projected commerce for the Basins. Additional dredging of channels would be required to obtain sufficient depths for the vessels expected to be serving the port in the future. Table 8-12 summarizes future harbor and channel requirements, and terminal and industrial land needs.

TABLE 8-12. Harbor and channel and terminal and water transport-oriented industrial land requirements, Cedar-Green Basins

	Harbor & Channel Req. (Vessel draft in Feet)			Terminal & Industrial Land (Acres)	
Year	Freighters	Bulk Carriers	Tankers	Total	Net Needs[1]
1963	--	--	--	2,800	--
1980	39	57	45	6,550	3,750
2000	40	71	47	7,300	4,500
2020	40	71	48	7,300	4,500

[1] Cumulative needs above 1963 land use.

Source: Appendix VIII, Navigation.

POWER

General

The only hydroelectric project in the Cedar-Green Basins is at Cedar Falls. The plant is owned and operated by the city of Seattle and has a total installed capacity of 22,856 kw. In addition, three steam electric plants are operated in the Basins. These consist of Lake Union (30,000 kw installed capacity), Georgetown on the Duwamish River (21,000 kw installed capacity), and Shuffleton on Lake Washington at Renton (90,000 kw installed capacity). The two former plants are owned by the city of Seattle while the latter is owned by the Puget Sound Power and Light Company. Additional power needs are purchased from outside sources, mainly the Bonneville Power Administration.

Present and Future Needs

The Basins' electrical energy needs are expected to grow even faster than the rate of population expansion. Additional power generation and transmission facilities would be necessary to meet these needs. There are several sites in the Basins having a potential for hydroelectric power development. These include four sites in the Green River watershed and one in the Cedar River watershed.

A number of thermal-nuclear power plants would be required in addition to power supplied from the Pacific Northwest regional system to meet the future needs of Puget Sound Area. The possibility of a nuclear-fired power plant being located in the Cedar-Green Basins is unknown at this time. Further location and environmental studies must be conducted before specific sites can be selected. Power needs are discussed further in the Area portion of this Appendix.

FLOOD CONTROL

General

The flood plains in the Cedar-Green Basins contain about 27,100 acres of land, with approximately 22,700 acres in the Green River Valley where the majority of the land is rapidly changing from agricultural to industrial, commercial and residential use. The Cedar River flood plain contains 800 acres and the Sammamish River flood plain 3,600 acres. Except for the Cedar River flood plain, frequent flooding is not a problem. However, extensive ponding from poor drainage occurs annually in the Green River flood plain. Average annual flood damages are estimated to be $117,000 in the Cedar Basin, $5,000 in the Sammamish River flood plain, and $325,000 in the Green Basin, according to 1966 prices and conditions. These damages result from the flooding and eroding of agricultural lands, urban and industrial areas, roads, railroads and flood protective works.

Table 8-13 lists the peak discharges and recurrence intervals of recent major floods on the Cedar River. Estimated flood damages are based on 1966 prices and conditions.

TABLE 8-13. Major floods and estimated damages, Cedar Basin

	Peak Discharge of Cedar R. At Landsburg (cfs)	Average Recurrence Interval (Years)	Current Estimated Damages
22 Dec. 1933	7,520	120	$1,188,000
11 Feb. 1951	6,200	50	597,000
30 Jan. 1965	4,640	11	216,000

Source: Appendix XII, Flood Control.

Existing flood control measures include a flood forecasting and warning service by the U.S. Weather Bureau; flood protection works consisting of channel improvements on the Cedar River, the Duwamish River and the Sammamish River, and levees along the Green River downstream from Kent; bank protection to control riverbank erosion, two Public Law 566 drainage projects along the Black River, a tributary of the Duwamish; and upstream storage behind Howard Hanson Dam on the Green River.

The Cedar River flood plain is subject to frequent flooding. Minor flooding and bank erosion occurs when riverflows exceed 1,570 cfs, a flow having a recurrence interval of once every year. A 100-year flood of over 7,500 cfs would inundate the entire valley.

Flooding in the Sammamish flood plain is minor. However, significant flood damage could result if unrestricted residential development is allowed to occur. The creeks in the low hills north of Lake Washington have shallow channels, rather flat gradients, and broad flood plains, and flood damage is significant.

The Howard A. Hanson Project is capable of reducing flood discharges at Auburn to 12,000 cfs for floods with a recurrence interval in excess of once in 100-years. Present flooding in the Green River flood plain results mainly from local inflow. Also high water in the Green River channel backs water in its tributaries to inundate commercial, industrial and residential developments as well as agricultural lands. 100 years. However, existing levees are incapable of carrying this flow safely. As an interim measure, pending channel improvements, flow at Auburn is being held to a maximum of 10,000 cfs. Present flooding in the Green River flood plain results mainly from local inflow. Also, high water in the Green River channel backs water in its tributaries to inundate commercial, industrial and residential developments, as well as agricultural lands.

Present and Future Needs

An increase in residential and industrial developments is anticipated in the flood plains throughout the Basins. At least a 100-year level of flood protection should be afforded to residential and industrial areas including that area along the Cedar River flood plain from the river mouth to the town of Maple Valley. The entire Green River flood plain should similarly be protected. The Sammamish Valley is protected from major spring floods with a recurrence interval of once in 40 years and winter floods of a magnitude of once every 10 years. The existing level of flood protection is adequate for the agricultural lands in the flood plain. Flood plain management is required to insure that future land use is compatible with the protection provided. The projected flood damage reduction needs are tabulated in Table 8-14 for each target date.

TABLE 8-14. Projected flood damage reduction needs,[1] Cedar-Green Basins

Year	Total ($1000)	Net Needs[2] ($1000)
1966	447	447
1980	780	780
2000	1,700	1,700
2020	3,740	3,740

[1] Based on 1966 prices and conditions.

[2] Damages which will occur without additional measures.

Source: Appendix XII, Flood Control.

WATERSHED MANAGEMENT

General

Watershed management comprises treatment measures for flood prevention, watershed protection and rehabilitation, urban and rural water management and erosion control.

The need in the Cedar-Green Basins is for implementation of integrated programs and projects for floodwater damage reduction and water management, with rehabilitation and protection of watershed lands according to use. The execution of these integrated programs and projects would meet the primary objectives, improve the quality of municipal and industrial water, enhance fish and wildlife habitat and opportunities for recreation, and improve the general environment.

Present and Future Needs

The needs for watershed management are complex, and two or more practices and measures may be required on the same area of land. Many measures and treatments become involved in integrated programs and projects. The watershed management needs for the Basin are tabulated in Table 8-15.

The broad needs for improved technology, program and projects are discussed in the Area portion of this Appendix.

TABLE 8-15. Total watershed management needs, Cedar-Green Basins

Year	Flood Prevention[1] (acres)	Watershed Protection & Rehabilitation (acres)	Water Management: Agriculture (acres)	Water Management: Urban (acres)
1980	50,400	704,200	10,600	264,900
2000	50,400	704,200	17,800	317,300
2020	50,400	704,200	23,700	433,700

[1] Includes flooding on main streams but not forested land within flood plain areas.

Source: Appendix XIV, Watershed Management.

RECREATION

General

The major attractions in the Cedar-Green Basins are the waters and shorelines of Puget Sound, Lake

Washington and Lake Sammamish. A twelve mile section of the Green River Gorge from the town of Kanasket to the Kummer Bridge is a unique area and has been aptly called "a ribbon of wilderness in our midst." The shorelines of the Cedar River, as well as many other rivers, streams, and smaller lakes, possess numerous recreation amenities. The urban parks within the Seattle metropolitan area are important recreation attractions which receive a large amount of use.

The Lake Washington Ship Canal, which connects Puget Sound with Salmon Bay, Lake Union, and Lake Washington, is utilized by many pleasure boaters. The Hiram M. Chittenden Locks are located on the downstream end of the Ship Canal at the entrance to Puget Sound. During 1962, the year of the Seattle World's Fair, over 80,000 vessels went through the locks. Almost 48,000 of these were pleasure craft. In addition, two million people visited the locks during 1962.

In 1964 there were 244 publicly-administered outdoor recreation areas within the Basins. The cities administered 171 areas, the State 38, counties 34, and Federal agencies 1. Of the total 16,600,000 visits estimated to publicly-administered recreation areas, 13,600,000 took place at city parks. Approximately 90 miles of river are considered to be suitable for boating.

Present and Future Needs

The present and future needs for water-related recreation, expressed in recreation days, are shown in Table 8-16.

TABLE 8-16. Present and projected water-related recreation demand, Cedar-Green Basins (1000's recreation days)

Year	Total	Net Needs[1]
1960	4,700	1,000
1980	9,400	5,700
2000	18,100	14,400
2020	33,600	29,900

[1] Cumulative needs above 3,700,000 recreation days satisfied by facilities existing in 1960.

Source: Appendix X, Recreation.

The existing supply of developed lands was inadequate to satisfy 1960 boating, camping, and picnicking demands. In addition to lands developed for boating facilities, an additional 1,580 rental moorage spaces were needed to satisfy 1966 boating demands. After 1970 the waters of the Cedar-Green Basins may become saturated, resulting in a "spill-over" of demand into adjacent basins.

In addition to indicated needs, urban parks, scenic routes, waterfront access, recreation rivers, special interest areas, interpretive facilities, open spaces and beaches and trails for activities other than swimming and hiking are necessary to satisfy the recreation and environmental needs.

FISH AND WILDLIFE

General

The Cedar-Green Basins contain about 220 miles of accessible main stem and tributary streams for the spawning and rearing of anadromous fish, principally chinook, coho, sockeye, and chum salmon, and steelhead and cutthroat trout. Resident game fish are found in all of the streams utilized by anadromous species, and in the various ponds and lakes.

The Basins are very highly developed industrially and, as a result, the potential for increased natural production of fish is limited. Major water diversions occur on both the Cedar and Green Rivers. Storage projects exist above the municipal water supply diversion structures.

Resident wildlife species are found throughout the Basins. Although intensively developed, the Basins have a high wildlife production potential due to an abundance of natural water areas and mild climate. However, extensive residential and industrial site development has greatly reduced wildlife habitat, and resulted in significant reduction of wildlife populations.

Present and Future Needs

There is a need to retain and expand fishing opportunities for trout, steelhead, salmon and other species in the Cedar-Green Basins. Similarly, there is a need to provide opportunities for hunting commensurate with the population growth. The projected fishing and hunting needs for the Cedar-Green Basins are shown in Table 8-17.

TABLE 8-17. Fish and wildlife, sport and commercial needs, Cedar-Green Basins

	Unit	1965 Total	1980 Total	1980 Net[1]	2000 Total	2000 Net[1]	2020 Total	2020 Net[1]
Sport Fishing								
Salmon	1000 User-Days	108	181	73	333	225	565	457
Game Fish	1000 User-Days	635	1,060	425	1,666	1,025	2,666	2,031
Marine Fish	1000 User-Days	12	17	5	22	10	29	17
Shellfish	1000 User-Days	8	11	3	14	6	19	11
Total		763	1,269	506	2,029	1,266	3,279	2,516
Hunting	1000 User-Days	55	105	50	171	116	211	156
Commercial Fishing	1000 Pounds			692		2,186		4,922

[1] Cumulative need above 1965 activity.

Source: Appendix XI, Fish and Wildlife.

COMPREHENSIVE PLAN

BASIS OF PLANNING

Desires of Local People

During a public hearing held in Everett (Snohomish Basin) on 22 October 1964, local interests from the Green and Cedar River Basins expressed a desire for improvements to reduce flood damages; an adequate water supply to serve municipal and industrial needs, construction of drainage facilities to permit use of lands for recreation, conservation and housing, water quality control and improvement, including continuation of closed watersheds until required for recreational use, preservation of salmon spawning areas, consideration of scenic and recreational resources, and retention of wild rivers in their natural state (see Appendix I, Digest of Public Hearings).

Summary of Basin Needs

The needs of the Cedar-Green Basins for 1980, 2000 and 2020 are summarized in Table 8-18.

TABLE 8-18. Summary of needs, Cedar Green Basins

Feature	Units	Cumulative Net Needs[1] 1980	2000	2020
M&I Water Supply	mgd	188.3	418.5	957.1
	(1000 Acre-ft.)	210.8	468.8	1,072.0
Irrigation	1000 Acre-ft.	0	1	2
Water Quality Control				
Waste	1000 Pop. Equiv.	1,787	3,414	6,086
Navigation				
Commercial	1000 Short Tons	9,200	19,800	37,200
Pleasure Boats	Wet Moorages	5,220	15,500	35,500
Power[2]				
Flood Control	$1000 Damage Reduction	780	1,700	3,740
Watershed Management				
Flood Prevention	1000 Acres	50.4	50.4	50.4
Watershed Protection & Rehabilitation	1000 Acres	704.2	704.2	704.2
Water Management				
Agricultural	1000 Acres	10.6	17.8	23.7
Urban	1000 Acres	264.9	317.3	433.7
Recreation	1000 User-days	5,700	14,400	29,900
Fish and Wildlife				
Sport				
Fishing	1000 User-days	506	1,266	2,516
Hunting	1000 User-days	50	116	156
Commercial Fishing	1000 Pounds	692	2,186	4,922

[1] See Water and Related Land Resource Needs for derivation of net needs.

[2] Power needs were projected for the Puget Sound Area only.

General Planning

A wide range of alternative nonstorage and management opportunities were viewed to meet the water supply needs of the Cedar-Green Basins. These include diversion structures, direct river pumping and treatment, desalinization, interbasin water transfer, further ground water utilization, and improved water yields through various watershed management practices. Levees, channelization, diversion, flood plain management, bank protection, and improved land use management practices were considered as possible means of meeting flood control and watershed management needs. Opportunities considered for satisfaction of water quality needs were sewage collection and treatment facilities, and minimum flows available to assimilate residual wasteloadings.

The water and related land resource was examined in terms of projected land use pattern C_2 (see Projected Land Use). Land needs of navigation, power, recreation, open space, greenbelts, and fish and wildlife were considered within this land use context.

There are a number of storage sites in the Cedar-Green Basins, both developed and undeveloped, which could provide additional opportunities for hydroelectric power production, flood control and enable further utilization of the resource in meeting municipal and industrial water supply needs and minimum stream flow requirements for anadromous and resident fish.

Preliminary investigations of storage capability

AD-A037 583 PACIFIC NORTHWEST RIVER BASINS COMMISSION VANCOUVER WASH F/G 8/6
COMPREHENSIVE STUDY OF WATER AND RELATED LAND RESOURCES. PUGET --ETC(U)
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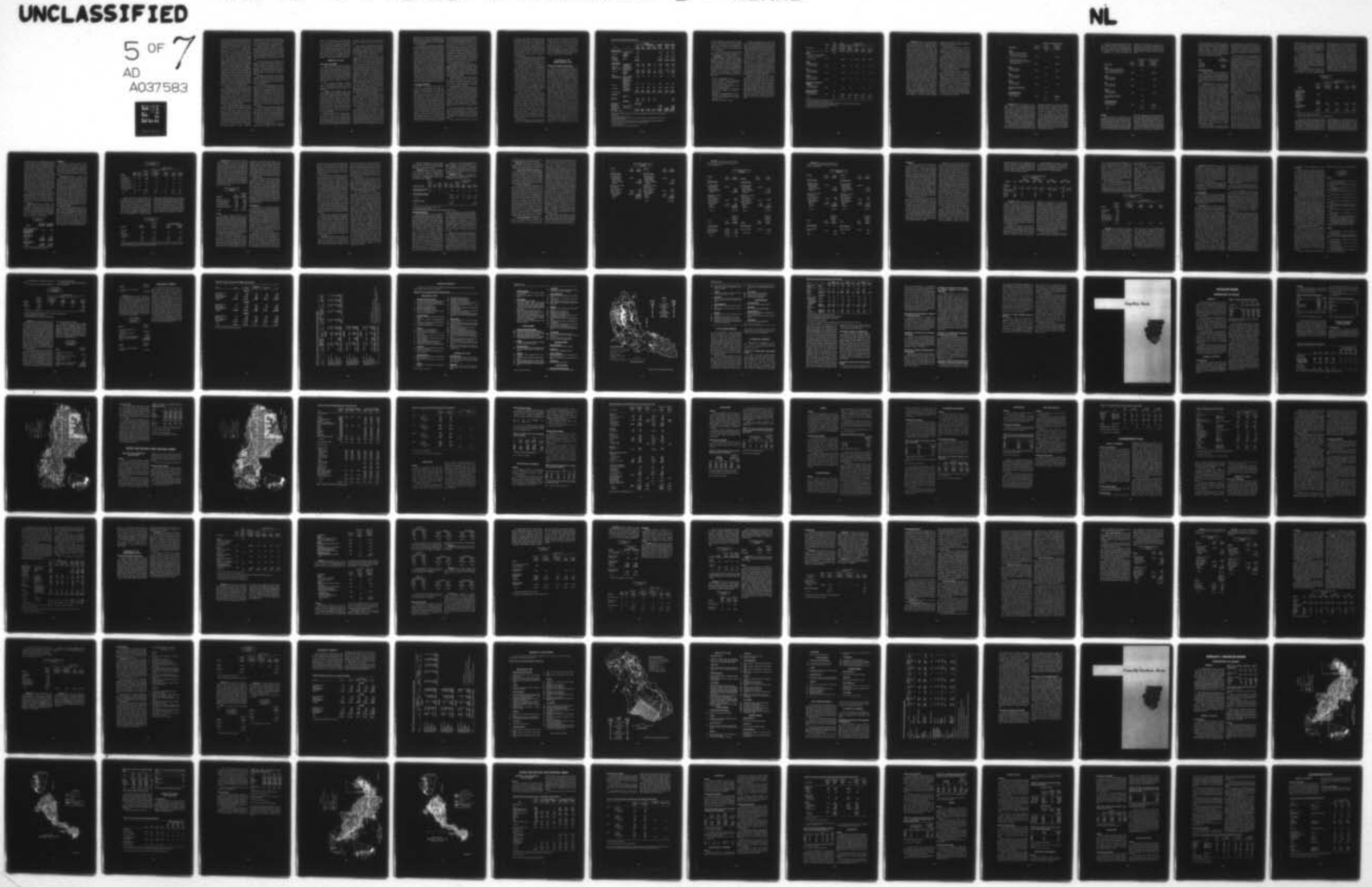

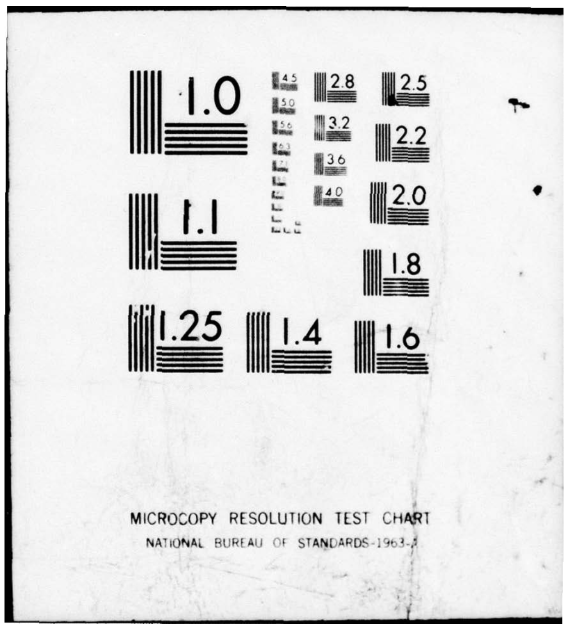
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within the Cedar River Basin were made of several possible sites, including Chester Morse Lake and a site located upstream from Chester Morse Lake at the mouth of Rex River. Development of the later site is compatible with additional storage at Chester Morse Lake which can be raised to a maximum pool elevation of 1,570, with a total usable storage of about 50,000 acre-feet. Lowering of the existing pen stock intake to Chester Morse Lake also may be feasible and would provide additional storage capacity at Chester Morse Lake beyond the 50,000 acre-feet. With development of the two storage sites, including lowering of the pen stock intake, a total of 100,000 acre-feet of storage capacity may be possible within the Cedar Basin. Approximately 50,000 acre-feet of storage at Chester Morse Lake is required to provide 100-year flood protection in the Cedar River flood plain in conjunction with levees. The additional 50,000 acre-feet of storage that may be possible from storage within the Basin could be used for municipal and industrial water supply storage and increased power production at the Seattle City Light plant at Cedar Falls. The flood control storage space could be utilized for conservation purposes from late spring to early fall to meet low flow augmentation needs of fish and supply water for future municipal use.

A storage site exists on Taylor Creek which joins the Cedar River about midway between Landsburg and Chester Morse Lake. About 10,000 acre-feet of storage could be developed at this site for flood control. However, the feasibility of conservation storage is questionable due to the geology of the basin which may not allow retention of water over a long period of time. Several other minor impoundment sites exist in the Cedar Basin but their storage capabilities are considered to be limited.

The existing Howard Hanson Dam on the Green River Basin provides protection against floods with a recurrence interval in excess of 100 years, limiting flows of the Green River at Auburn to 12,000 cfs. This project has a storage capacity for flood control of 106,000 acre-feet. A conservation pool is currently held at the project during the spring and summer months for use in meeting fish needs. About 25,000 of a possible 95,000 acre-feet of conservation storage is used. The increased conservation storage as discussed in the Comprehensive Plan for the Puyallup River Basin is planned as a source of additional municipal and industrial water supply for the city of Tacoma. However, a portion may be made available for low flow augmentation to meet fish and water quality needs in the lower Green-Duwamish River.

Additional storage is possible in the Green River Basin above Howard A. Hanson Dam at Sunday and Smay Creeks and at Weston on the Green River located approximately 20 miles upstream from Hanson Dam. Only preliminary investigations have been made, but an additional 100,000 acre-feet of storage may be feasible by construction of projects at these sites.

Alternative objectives were considered in developing the Comprehensive Plan. The objectives represented both ends of the spectrum of interests, i.e., economic efficiency and environmental quality as discussed in the Puget Sound Area section of this Appendix. The alternative elements considered in plan formulation are described under Alternative Elements.

The single-purpose Appendices, V through XIV, provided a wide array of solutions. Necessary adjustments were made to these solutions in the formulation of a comprehensive plan for the Basins. These adjustments consisted of:

(a) Flood control storage projects, contained in Appendix XII, of Lake Sammamish and on Taylor Creek were not used. Further levee and channel improvements on the Sammamish River also were not included in the Comprehensive Plan. Flood plain management for the Sammamish Basin and levees and channel improvements for the Cedar River were considered to be better solutions for the long-range period. The Sammamish River and Taylor Creek would be left in their natural free flowing states. Storage on Taylor Creek could probably be single-purpose only, as retention of a conservation pool is questionable.

(b) Municipal and industrial water supply projects contained in Appendix VI were modified with construction of a fourth pipeline on the Cedar River eliminated. This was done to allow multiple-purpose use of the water for maintenance and enhancement of the anadromous and resident fishing through low flow augmentation, for maintenance of Lake Washington above El. 20.0, and for water quality control of Lake Washington and Lake Union.

(c) Fish and wildlife measures contained in Appendix XI were modified with a fish passage

facility at the Landsburg Diversion Dam eliminated due to the need for further studies. The possible conflicts with municipal and industrial water quality must be examined and resolved before this measure can be implemented. Equivalent production of salmon and steelhead could be provided through artificial propagation facilities. However, should future studies reveal fish use of the spawning beds above the diversion dam to be compatible with water supply use, then this measure should be undertaken.

SUMMARY OF PLAN

Early Action 1970-1980

During this period municipal and industrial water supply needs of the city of Seattle and its service area, which includes Bellevue, would be satisfied through construction of a diversion facility on the North Fork of the Tolt River in the Snohomish River Basin. Ground water resources would continue to supply small and rural communities, with industry meeting a portion of its future growth in water supply requirements by pumping from nearby surface waters.

No new cropland is expected to be placed under irrigation during this period. A continual decrease of irrigated land is anticipated due to an expansion of residential housing and industry into farming areas.

Compliance with Washington State water quality standards would be obtained through installation of adequate collection and treatment facilities by a number of communities and cities in the Basins. Continued expansion of the Metro waste collection and treatment system is planned. Several outfall facilities located along the Puget Sound shoreline would be improved to assure adequate disposal of treated wastes. Further monitoring, evaluation, and information collection for control purposes would be undertaken to insure compliance with State standards. A comprehensive sewerage plan would be developed for the Basins.

Navigation needs would be met through channel deepening projects on the Duwamish River waterways and through retention of lands found to be suitable for terminal or water transport-oriented industrial development. Pleasure boating needs would be met through full development of potential sites for small boat harbors in the Basins. Moorages would be provided for pleasure boaters through the construction of three small boat harbors with 2,100 moorage slips.

Power needs for the Basins would be satisfied by a Northwest Regional System which is discussed under Power in the Area portion of this Appendix. Power facilities could be constructed in conjunction with the multiple-purpose storage project planned on the Cedar River at Chester Morse Lake.

A multiple-purpose storage project on the Cedar River at Chester Morse Lake would provide 50,000 acre-feet of flood control storage which, together with additional levees and channel work planned after 1980, would provide the Cedar River flood plain with protection against floods with a recurrence interval in excess of 100 years. In the Green River flood plain levee and channel work along the Green River below Auburn is planned to provide a channel capacity capable of accommodating the 12,000 cfs of controlled flow release by Howard A. Hanson Dam at Auburn, and the additional water pumped into the river by the valley drainage projects located on either side of the river. These projects provide for the removal of valley drainage through pumping plants and collection channels. The flood plain of the Green River valley would have protection in excess of 100 years as a result of these projects. Flood plain management is relied upon to retain the open space and greenbelts remaining in the Sammamish River drainage and to guide future use of the Cedar and Green River flood plains consistent with the degree of flood protection provided.

Two small watershed multiple-purpose projects are planned for installation prior to 1980 to achieve damage reduction and water management. One project is located in the Swamp-Bear-North Creek watershed and the other in the Evans Creek watershed, both tributary to the Sammamish River. These structural improvements would be complemented by ongoing and accelerated land treatment measures.

Campgrounds, picnic areas, beaches, and boat launching ramps would be developed on existing public lands, together with the acquisition of additional land and water areas to satisfy recreational needs. Additional land and water areas would be acquired along the Puget Sound shoreline to provide badly needed marine parks. Over 50 recreation sites are planned for improvement or development before 1980 with many sites located within the urban areas. The plan calls for the preservation and the public

accessibility of the many natural attractions in the Basins, including the shoreline of Puget Sound, Lake Washington, Lake Sammamish and a 12-mile section of the Green River Gorge from the town of Kanasket to the Kummer Bridge.

Land acquisition including access and fish and wildlife enhancement projects would be undertaken to increase the opportunities for this form of outdoor recreation. Additional trout hatcheries and artificial propagation facilities for salmon and steelhead, including rearing ponds and spawning channels, would be constructed. Low flow augmentation would be provided through additional conservation storage from Howard Hanson Dam on the Green River and through releases from the proposed Chester Morse Lake multiple-purpose project on the Cedar River. Modification of the salt water drain outlet and construction of a second fish ladder at the Hiram M. Chittenden Locks, at the entrance to the Lake Washington Ship Canal, would provide improvements in fish passage at that facility. Important cross-sectional stream surveys would be taken during this period in order to determine the minimum and optimum streamflows required for fish production. Subsequent to these cross-sectional surveys, further studies of the new projects may be required as well as reconsideration of the operation procedures of existing projects.

Long-Range, 1980-2020

Expansion of the Seattle water system to satisfy the year 2000 demand may require construction of additional storage in the Cedar River watershed on the Rex River or on the main stem upstream from Chester Morse Lake. Some of this water could be provided from the conservation pool made possible by increased storage at Chester Morse Lake, proposed as an early action project to meet flood control and low flow augmentation needs of fish. A third pipeline would be constructed from the Cedar River during this period. However, additional water supply would be needed to fully meet the 2000 level of demand generated by the Seattle service area. This water would be obtained from the North Fork of the Snoqualmie River with releases from water stored by the North Fork multiple-purpose project planned for implementation prior to 1980. Ultimate water supply needs of the city of Seattle could be met through development of the North Fork of the Skykomish River, although this source is considered to be tentative due to the technological changes that are expected prior to the time when this project would be needed. Recycling of water by industry and other innovations would probably preclude the necessity of this project allowing the retention of the North Fork in a free-flowing state. The small communities would continue to be supplied from their existing sources of ground water until such a time as these resources become exhausted or are used to their ultimate limit. Provisions have been made for the smaller water purveyors, including Renton, Kent and Auburn, to be supplied from Tacoma and Seattle water systems when needed. Industry currently using nearby surface waters are expected to continue doing so primarily for washing purposes. These flows are normally returned to the river a short distance from the point from which they were diverted.

An additional 800 acres is expected to be placed under irrigation during this period, with water supplied primarily from the Green River as these lands are located in the upper Green River Valley above Auburn. A net decrease in the total number of acres irrigated in the Cedar-Green Basins is expected from the 2,600 acres irrigated in 1966 to a projected 1,100 acres by the year 2020.

Existing treatment in collection facilities would be expanded commensurate with the growth of the population and industrial development to insure that State water quality standards are continually met. A water quality monitoring, evaluation and control program would be maintained.

Significant increases in small boat harbor development are forecast for this period, with over 10,000 wet moorages to be provided by the development of five small boat harbors. All lands that have been designated as having a favorable potential for terminal and water transport-oriented industrial development in the Cedar-Green Basins are expected to have been developed by this period. Joint development of navigation facilities may occur with authorities in adjacent basins. The Snohomish Basin is viewed as having an excellent potential for a large port development.

No power development is anticipated in these Basins in the long-range period, with importation of power viewed as being the means for satisfying power needs. The Northwest Regional Power System has been planned with consideration given to the load requirements of the highly populated Cedar-Green Basins.

The only additional flood control structures en-

visioned after 1980 would be construction of levees and channel improvements along the Cedar River from River Mile 4.5 to about 17.5 near Maple Valley. This work in conjunction with the storage from the Chester Morse Lake project would provide protection in excess of 100 years for the Cedar River flood plain downstream from Maple Valley. Remaining portions of the Cedar flood plain are recommended for flood plain management; namely, zoning to insure that developments are consistent with the degree of protection provided.

Further programs and projects would be undertaken to satisfy watershed management needs. These include six multiple-purpose projects primarily on the Cedar and Green Rivers and a program of technical assistance, land treatment, and water management.

Additional development of campgrounds, picnic areas and other recreational facilities would be undertaken after 1980 at over 70 sites throughout the Basins, on public lands as well as on private lands with both public and private sectors participating in the providing of recreation facilities. In the long-range period, development of recreation facilities in the municipal watersheds may be required to satisfy recreation needs. Detailed studies are required which adequately demonstrate this need as well as evaluate the economic feasibility of recreation use, taking into account treatment plant construction costs, if warranted. Portions of the Sammamish, Cedar and Green Rivers and tributaries may be included in a State system of scenic and recreation rivers for retention in a free-flowing state for public use.

Additional fish and wildlife opportunities would be provided through anadromous and resident fish enhancement measures. A facility may be constructed on the Green River to provide passage up and downstream from Howard Hanson Dam. Details and actual feasibility of this project would be determined in studies undertaken prior to 1980. Clearance improvement of 2 miles of Burns and Crisp Creeks and six miles of channel on three other streams would be undertaken during this period, together with construction of spawning channels to provide opportunities for enhancement of anadromous fish runs. Artificial propagation measures including hatcheries or their equivalent also would be provided to meet growth in both the sport and commercial fisheries.

Table 8-19 summarizes the Cedar-Green Basins elements of the Comprehensive Plan, showing benefits and costs for the early action of the Plan, and provides a summary of investment costs by water resource features for the entire 50-year period ending in 2020. The early action of the plan includes programs amounting to \$229,941,000 and projects costing \$218,615,000 for a total investment of \$448,556,000. Program and project investment cost for the 1980-2000 period amount to \$671,084,000 and for the 2000-2020 period \$682,599,000, for a total 50-year investment of \$1,802,239,000.

FEATURES OF THE COMPREHENSIVE PLAN

Municipal and Industrial Water Supply

The city of Seattle is expected to remain as the major purveyor of municipal and industrial water in the Cedar-Green Basins. Approximately 70 percent of the Basins' water needs in 2020 are anticipated to be provided by the Seattle Water Department, with nearly 90 percent of the total municipal demand and about 50 percent of the total industrial demand met by the department. The communities of Renton, Kent, and Auburn would continue to be supplied from existing ground water sources. However, when and if these sources become exhausted, the communities of Renton and Kent could be supplied by the Seattle Water Department and Auburn could be supplied by the Tacoma Water Department. The self-supplied water using industries are located at sites along the major watercourses, which provide, in most cases, an adequate supply of untreated industrial water. Ground water supplies would continue to be utilized by rural communities and private residents in outlying areas. The economies of scale associated with water supply development by large water purveyors, such as the cities of Seattle, Tacoma, and Everett, should provide the least cost source of water for smaller communities other than ground water or diversion from nearby streams. Equitable wholesale water rates are necessary, however, to insure that cost savings are passed onto all those served by the large water purveyors. Without an equitable rate structure, suburban communities may, in fact, be able to develop their own water supplies at less cost. Also, the development by large water purveyors is considered to be in the overall best interest of environmental quality as a minimum number of possibly

TABLE 8-19. Comprehensive Plan, Cedar-Green Basins

Feature	Item	1970-1980 Investment[1] Costs ($1000)	1970-1980 Average Annual Costs ($1000)	1970-1980 Average Annual Benefits Gross ($1000)	1970-1980 Average Annual Benefits Net ($1000)	1980-2000 Investment Costs ($1000)	2000-2020 Investment Costs ($1000)	1970-2020 Investment Costs ($1000)
Management Programs								
Water Quality Control	Monitoring, Evaluation and Control	3,400				4,840	5,320	13,560
Flood Control	Flood Plain Management	147				240	240	627
Watershed Management	Programs	225,954				230,301	230,044	686,299
Fish & Wildlife	Programs	440				602	776	1,818
Total Programs		$ 229,941				$ 235,983	$ 236,380	$ 702,304
Non-storage Projects								
M&I Water Supply	Ground Water Use	2,400	362	362[7]	0	3,780	5,760	111,940
	Surface Water Use	19,304	2,973	2,973[7]	0	10,140	22,087	51,531
Irrigation Water Supply	Ground Water Use	0	0	0	0			0
	Surface Water Use	0	0	0	0	55	55	110
Water Quality Control	Sewerage Treatment & Collection Fac.	113,850	6,770	6,770[7]	0	275,800	237,000	626,650
Navigation	Channels	3,779	191	339	148	0	0	3,779
	Small Boat Harbors[1]	(4,139)[3]	(280)[3]	(391)[3]	(111)[3]	(20,196)[3]	(0)	(24,335)
Power[2]								
Flood Control	Channel and Levees	12,000	601	723	122	1,300	0	13,300
Watershed Management	Floodwater Damage Reduction, Water Management and Rehabilitation and Protection of Watershed Lands	2,180	119	242	123	5,510	200	7,890
Recreation	Land Acquisition, Access & Recreation Fac.	54,425	3,792	4,560	768	70,000	104,600	229,025
Fish & Wildlife	Land Acquisition, Access & Enhancement Facilities	5,067	438	1,026	588	7,916	16,517	29,500
Total Non-Storage		$ 213,005	$15,246	$16,995	$1,749	$ 374,501	$ 386,219	$ 973,725
Storage Projects								
	Chester Morse Lake[4]							
Flood Control		4,740	263	298	35			4,740
Fish & Wildlife		870	49	55	6			870
	Total Project	5,610	312	353	41			5,610
	Howard Hanson							
Water Quality Control		(Not evaluated)						
Fish & Wildlife		(Not evaluated)						
M&I Water Supply	N. Fork Snoqualmie[6]					47,600[5]		47,600[5]
M&I Water Supply	Cedar River					13,000[5]		13,000[5]
M&I Water Supply	N. Fork Skykomish[6]						60,000[5]	60,000[5]
Total Storage		$ 5,610	$ 312	$ 353	$ 41	$ 60,600	$ 60,000	$ 126,210
Total Program and Projects		$448,556	$15,558	$17,348	$ 1,790	$671,084	$682,599	$1,802,239

[1] Includes cumulative annual program costs for the period for management features and capital costs for non-storage and storage projects.

[2] Power facilities not included in basin plan.

[3] General Navigation facilities costs and benefits for public small boat harbors only. Total pleasure boat facilities costs and benefits included with Recreation.

[4] Power and municipal, and industrial water supply benefits from increased storage at Chester Morse Lake not evaluated.

[5] Includes total costs for municipal and industrial water supply and transmission lines.

[6] Located in Snohomish Basin.

[7] Average annual benefits assumed equal to average annual costs.

disruptive impoundments and structures are placed on streams, rivers and lakes. More of these resources are left in their natural state for the satisfaction of environmental needs than if each individual water district sought to satisfy its own needs through resource development.

The Cedar-Green portion of the Comprehensive Plan dealing with municipal and industrial water supply is discussed by the following time periods:

1970-1980–The city of Seattle water system is capable of meeting its projected needs, without provision for fish flow releases at the Landsburg Diversion Dam, to about the year 1975. The Washington State Department of Fisheries pursuant to Section 3, Chapter 284, Laws of the State of Washington (extraordinary session, 1969) has requested (December 18, 1969) that the following minimum flows be established for the purpose of protecting fish resources of the public waters of the Cedar River which is tributary to Lake Washington and located in King County:

October 1 through October 5: 265 cfs
October 5 to October 11: Linear increase from 265 cfs on October 5 to 435 cfs on October 11
October 11 through June 15: 435 cfs
June 15 to July 1: Linear decrease from 435 cfs on June 15 to 90 cfs on July 1
July 1 through September 11: Linear increase from 90 cfs on August 15 to 150 cfs on September 11
September 11 through September 20: 150 cfs
September 20 to September 26: Linear increase from 150 cfs on September 20 to 265 cfs on September 26
September 26 to October 1: 265 cfs

The State of Washington has not acted on the above request with adjudication of the Seattle's water right to the Cedar River required before the minimum flows can be firmly set. Under existing conditions the minimum flows requested for July 1 through August 15 can normally be met without reducing the water required to service the existing two pipelines. Should minimum releases at the Landsburg Dam become mandatory for fish use, additions to the system could be required earlier. Construction of a diversion dam on the North Fork of the Tolt River is recommended prior to 1975 as a means of expanding supply capability to meet the 1980 level of needs. Water from the North Fork would be diverted into the existing Seattle Water Department Tolt River regulating basin and hence piped to the city's distribution works. The North Fork project would increase the existing average daily supply by 65 mgd for a total system capability of 280 mgd average daily flow. This would satisfy the city's needs to about 1985.

Additional groundwater utilization is planned for Renton, Kent, and Auburn in order to satisfy their projected water supply needs, along with other small and rural communities. Chemical, metal and petroleum industries, together with wood products, stone, and clay industries would add capability to existing self-supplied water systems commensurate with projected outputs. These industries would derive approximately 98 percent of their water from natural water courses near plant sites. The projected average daily water use for the Cedar-Green Basins planned supply and transmission investments and average annual costs are shown in the following tabulation for 1980.

Development	Needed by Year	1980 Average Daily Water Use (mgd)	Supply, Transmission & Treatment Investment ($1000)	Average Annual Costs: Interest & Amort.[1] ($1000)	Average Annual Costs: O&M[2] ($1000)	Average Annual Costs: Total ($1000)	Benefits[3] ($1000)
Seattle[4]		258					
Contruction of diversion dam & transmission facilities on N. Fork Tolt River	1975		16,600	776	1,780	2,556	2,556
Renton		13					
Additional ground water development	1975		900	70	107	177	177
Kent		4					
Additional ground water development	1975		420	32	35	67	67
Auburn		6					
Additional ground water development	1975		540	42	31	73	73
Small and Rural Community Systems		16					
Additional ground water development	1980		540	42	3	45	45
Self-Supplied Industry		56					
Additional surface water development	1970		2,704	210	207	417	417
Total		353	$21,704	$1,172	$2,163	$3,335	$3,335

1 Interest and amortization of capital investment costs.

2 Total incremental increase in annual operation and maintenance costs, including pumping and treatment costs.

3 Average annual benefits assumed equal to average annual costs.

4 Seattle service area includes city of Bellevue.

1980-2000—Expansion of the Seattle water system to partially satisfy the 2000 level of demand would require construction of additional storage in the Cedar River watershed on the Rex River or on the main stem upstream from Chester Morse Lake. Approximately 38,000 acre-feet of storage space would be required to supply the additional 65 mgd average daily flow associated with construction of a third pipe line, assuming that the water needs during the months of June through October would be satisfied only from storage. A portion of this volume of water could be provided from the conservation pool made possible by increased storage at Chester Morse Lake, proposed as an early action project to meet flood control and the low flow augmentation needs of fish. The exact amount of storage to be used for municipal and industrial water supply would depend on the adjudication of Seattle's water rights and rulings by the State of Washington in setting minimum flows for fish. Alternatives to further dam construction include the possibility of lowering the intake between Chester Morse Lake and the Masonry Dam, located about one mile downstream. A portion of the over 30,000 acre-feet of dead storage at Chester Morse Lake could be used by installing a tunnel or siphon. Sealing off the Masonry Pool thereby enabling completion and use of the Masonry Dam, also is a possible alternative. However, for purposes of this study, additional storage constructed at the Rex River was assumed as a means of supplying the third pipeline to provide the incremental gain in water supply for the Seattle system. Detailed engineering and economic studies are required to determine the optimum storage project or projects in the Cedar River watershed.

During this period, utilization of water from the North Fork Snoqualmie project is viewed as necessary in order to satisfy the 2000 level of water supply demand generated by the Seattle service area.

An additional average daily supply of 180 mgd is considered possible from the North Fork Snoqualmie project by raising the dam, increasing storage by approximately 62,000 acre-feet, and by transferring about 120 cfs of water from power use. Total developments during this period on the Cedar and North Fork Snoqualmie Rivers would increase the Seattle system capability by 245 mgd to approximately 525 mgd average daily flow, satisfying the city's needs until about year 2010.

Further groundwater utilization is planned for Renton, Kent, and Auburn, with no expansion of water supply anticipated for small and rural communities. If the increase in water demand on these community water systems exceeds the capability of the groundwater resources, water can be provided from the Seattle Water Department in the case of Renton and Kent, and from the Tacoma Water Department in the case of Auburn. The self-supplied industries are expected to increase the capacity of their systems, consistent with projected output. A summary of projected average daily water use and investment costs is shown in the following tabulation for municipal and industrial water supply developments required by the year 2020.

Development	Needed by Year	2000 Average Daily Water Use (mgd)	Supply, Transmission & Treatment Investment ($1000)
Seattle		387	
Additional storage Cedar River Watershed and construction of 3rd Cedar River transmission line	1985		13,000
Additional storage at N. Fork Snoqualmie Reservoir & construction of transmission lines.	1995		47,600
Renton		30	
Additional ground water development	1995		2,100
Kent		10	
Additional ground water development	1995		840
Auburn		14	
Additional ground water development	1995		840
Small and Rural Communities		15	
None			
Self-Supplied Industry		126	
Additional surface water development	1990		10,140
Totals		582	$74,520

2000-2020–During this period the city of Seattle would need to develop additional surface water in order to satisfy its 2020 level of demand. For purposes of this study a storage project on the North Fork Skykomish River has been provided in the Comprehensive Plan as a means of satisfying Seattle's water supply needs through 2020. Water from nuclear-powered desalinization plants also was considered, but is not viewed as a viable alternative at this time. No nuclear-powered plants are under consideration for siting in the Cedar-Green Basins, or in the adjacent Puyallup and Snohomish Basins. The cost of piping water from a distant desalinization plant would exceed that of transmitting water from the North Fork Skykomish River. However, future unforeseen developments could alter this judgment. Recycling of water by industry and other technical innovations which may certainly be expected in the next 40 years would probably preclude the necessity of this project, allowing the retention of the North Fork in a free-flowing state. In order to satisfy Seattle's municipal and industrial water supply needs, a total system capability of 695 mgd is required by the year 2020. The needed supply increase of 170 mgd (695 mgd needed compared to 525 mgd available) can be obtained from the North Fork project. Preliminary examination of the North Fork resource indicates that this amount of water could be provided with storage, in most cases leaving a significant quantity of water for fish use.

During this same period, expansion of groundwater supplies by Renton, Kent, and Auburn is projected, assuming that the groundwater resources are adequate to meet these future needs. Should these cities' groundwater resources become exhausted, they can supplement their supply from Seattle and Tacoma. Further diversions of surface water for industrial use is anticipated and provided for in the Comprehensive Plan. A summary of projected average daily water use and investment costs is shown in the following tabulation for projects required by the year 2020.

Development	Needed by Year	2020 Average Daily Water Use (mgd)	Supply, Transmission & Treatment Investment ($1000)
Seattle			
Multiple-purpose storage project on N. Fork Skykomish River and construction of transmission lines	2010	695	60,000
Renton		63	
Additional ground water development	2010		3,300
Kent		17	
Additional ground water development	2015		900
Auburn		25	
Additional ground water development	2015		1,560
Small and Rural Communities		14	
None			
Self-Supplied Industry		306	
Additional surface water development	2010		22,087
Total		1,120	$87,847

Irrigation

The crops grown in the fertile soil of the bottomlands lying north of Auburn and between Bothell and Lake Sammamish are intensively farmed and irrigated. However, irrigation has been steadily decreasing during the past few years due to rapid expansion of housing and industry into the irrigated area. Appendix VII, Irrigation, indicates that irrigated acreage in the Basins would decrease from the present 2,600 acres to 300 acres in the near future. However, by the year 2020, 800 acres of lands located in the Green River valley upstream from Auburn are expected to be placed under irrigation The net result is a decrease of the present 2,600 acres irrigated to 1,100 acres by 2020. Water supplies for the new lands to be served by pumping from the Green River would result in only a net depletion of about 1,600 acre-feet annually for the total projected irrigated land of

1,100 acres. Appendix VII schedules no new irrigation development between now and 1980. However, 400 acres of land are scheduled to be developed and irrigated during the periods 1980-2000 and 2000-2020. Irrigation is anticipated to be by private means, with individual farmers pumping from the Green River. The projected irrigation investment costs for the Green Basin are shown below:

Period	Private Investment Costs
1970-1980	--
1980-2000	$55,000
2000-2020	$55,000

Water Quality Control

A significant investment would be required to meet the present and future waste collection and treatment requirements in the Basins. Studies show that the minimum historical flows in the Green River would generally be adequate to assimilate projected residual wasteloadings without deteriorating water quality.

1970-1980–During this period, completion of the waste collection and treatment program currently under way by Metro, is anticipated. With completion of this program, more than 60 percent of the total land area within the Basins would be provided service by the Metro sewage system. Separation of storm and sanitary sewers is planned in order to eliminate all overflows into Lake Washington, thereby helping to improve its quality. This work would provide completely separate storm sewer systems for all of that part of the city of Seattle draining directly into Lake Washington, for the area in West Seattle tributary to Alki Point treatment plant, and for several smaller areas throughout the city where sewer back-ups have occurred because of inadequate capacity. Industrial treatment costs are rather insignificant in comparison to the required investments for municipal and recreational waste treatment facilities. This is due to the lack of large organic waste-producing industries which enable most industrial waste to be discharged directly into the municipal system with minimal cost. Some industrial wastes, however, particularly those of the metal-plating industry, would require special treatment methods prior to discharge.

A monitoring system for both fresh and marine waters is essential to allow for the immediate analysis and interpretation of data, thereby proving to be a useful and effective management tool. The monitoring program by Metro and the U.S. Geological Survey is considered to be adequate for these Basins. A comprehensive sewerage plan would be developed for the Basins with updating of the Metro plan undertaken.

Continual observations of Lake Washington and its rate of recovery from near eutrophication are recommended during this period to verify that current trends in nutrient reduction support tentative conclusions reached by the Water Pollution Control Commission. These findings indicate that the planned third pipeline for additional diversion of municipal and industrial water supply by the city of Seattle would not adversely affect lake water quality as, at least by 1985 (approximate year of planned diversion), nutrient levels of the lake should be reduced below that required to obtain a condition of transparency and oxygen level equal to or better than that of 1950. Inflows from the Cedar River are not expected at that time to materially affect the lake's quality. However, as further withdrawals from the Cedar River would reduce the quality control of Lake Washington, the above conclusion should be re-examined prior to installation of the third pipeline. Minimum inflows from the Cedar River also are needed to maintain Lake Washington above El. 20.0 during late summer as a result of lockages at the Hiram M. Chittenden Locks.

Problems associated with operation of the Chittenden Locks due to salt water intrusion are considered to have been effectively controlled with construction of a salt water barrier, which has reduced the amount of fresh water needed to service the salt water drain (located upstream from the locks) by 30 percent or more. Preliminary studies indicate that Lake Washington storage withdrawals, needed during low inflow periods as supplemental water for servicing the drain, would lower the lake level below elevation 20.0 on a probable frequency of no more than once every ten years, and below elevation 19.0 no more than once every 100 years. Prior to installation of the salt water barrier, the lake was drawn down below an elevation of 20.0 eleven out of thirty-three years, and below elevation 19.0 three times in this same period. These studies presumed that water diversion by the city of Seattle of natural flows did not exceed the 1966 level of an average of 209 cfs from June through October. However, should detailed economic studies indicate the desirability for

complete adherence to a minimum lake elevation 20.0 or that future lockages would be greater than current levels, additional measures may be required in order to comply with water quality standards set by the Pollution Control Commission, including use of a thrift lock or curtailment in lockages.

The Comprehensive Plan proposes flow releases at the Landsburg Diversion Dam, supplementary to natural inflows between Landsburg and Renton, to provide a minimum of 100 cfs as measured at the Renton gauge for fish use from June through August. This minimum flow is expected to insure that both the nutrient balance problems at Lake Washington and the water supply needs associated with operation of the locks are satisfied.

The Comprehensive Plan also adopts in total the requirements for meeting the existing water quality standards as set forth in the Implementation and Enforcement Plan for Interstate Waters, 1967, and Intrastate Waters, 1969, of the State of Washington. The Plan calls for secondary treatment of all waste discharges. However, if the receiving water course is marine water and the outfall and dispersion studies indicate primary treatment with a deep water outfall are adequate to protect the water quality, secondary treatment would not be required by the Washington State Pollution Control Commission. Water quality problems of Lake Union, associated with sludge deposits, should be investigated and corrected. The investment costs of waste treatment and collection facilities called for by 1980 are estimated below for municipalities, which include industry and recreational development within the Cedar-Green Basins. Also shown are the program costs of water quality surveillance during this period.

Water Quality Control
1970-1980

Feature	Investment Costs ($1000)	Average Annual Costs: Interest & Amortization ($1000)	Average Annual Costs: O&M ($1000)	Average Annual Costs: Total ($1000)	Average Annual: Benefits[2] ($1000)
Monitoring, Evaluation & Control Program	3,400[1]				
Industrial Wastes					
Treatment	0	0	0	0	0
Municipal Wastes					
Treatment	27,750				
Sewers	83,250				
Subtotal	111,000	$5,190	$1,355	$6,545	$6,545
Recreation Wastes					
Treatment	2,850	133	92	225	225
Total	$117,250	$5,323	$1,447	$6,770	$6,770

[1] Cumulative annual program costs for the period.

[2] Average annual benefits assumed to be at least equal to average annual costs.

Water quality problems associated with residual BOD loadings do not exist in the Cedar River, as only limited wastes are discharged into that river, usually from septic tank fields of homes located along the river. However, residual BOD loadings from the combination of raw sewage outfalls, inefficient treatment plants and Metro's new plant has created an additional demand on the dissolved oxygen in the lower Duwamish River. Without storage, there are insufficient flows during the late summer and early fall to assimilate the residual BOD in the lower Duwamish during certain tidal periods. This problem is expected to be resolved when Metro intercepts the raw sewage outfalls and inefficient treatment plants.

Over 90 percent of the total BOD load to the river would be removed upon interception by Metro of the existing raw sewage discharges. However, if Metro's monitoring program shows that a problem exists after all of the sewage is being treated at Metro's plant, it would be Metro's responsibility to correct the problem by tertiary treatment, diverting the effluent to Puget Sound or by some other means to maintain water quality standards. The hydrodynamics of tidal flow and associated dissolved oxygen levels in the Duwamish River are complicated with no evidence having been provided, to date, of fish kills or direct deleterious effects on water quality resulting from effluent discharges by the Renton Treatment Plant. Other water quality needs, including those of Lake Sammamish and other waters in the Cedar and Green River Basins, can be met with the construction of proper sewage collection and treatment facilities.

A study has been made by Metro for diverting the Renton plant effluent into Puget Sound with cost estimates prepared for constructing a pipeline from the treatment plant to the Sound, as Metro is committed to diversion of the treatment plant effluent if water quality conditions in the Duwamish River so dictate.

1980-2020–During the periods 1980 to 2000 and 2000 to 2020, expansion by industry, new developments, and growth of urban and recreation areas would correspondingly require that new sewer interception systems be installed and treatment facilities be enlarged and/or constructed. Summarized below are estimated investment costs for water quality control by sectors for each period.

Water Quality Control
1980-2020

Feature	Investment Costs ($1000) 1980-2000	2000-2020
Monitoring, Evaluation & Control Program	4,840[1]	5,320[1]
Industrial Wastes		
Treatment	0	0
Municipal Wastes		
Treatment	68,000	59,000
Sewers	202,000	175,000
Subtotal	$270,000	$234,000
Recreation Wastes		
Treatment	5,800	3,000
Total	$280,640	$242,320

[1] Cumulative annual program costs for the period.

Navigation

Navigation is projected to continue to be an important segment of the economy of the Cedar-Green Basins. The Port of Seattle is anticipated to pursue a program of rehabilitation and development of new Port terminal facilities that would serve a well-developed and diversified traffic base. A discussion of the navigation development by time periods follows:

1970-1980–Development of additional lands for water transport-oriented industry and deep draft terminals is called for during this period. Lands along the Duwamish River waterways, Elliott Bay, and other portions of the Seattle Harbor are considered suitable for water transport-oriented industry as well as additional terminal development. Lands in the Green River Valley (Tukwila), along the Lake Washington Ship Canal, south and east of Lake Washington, and north of Seattle near Edmonds also are suitable for water transport-oriented industry. Many of the water-side land areas along the Duwamish waterways can be improved through the use of dredge-fill derived from channel improvement projects needed during this period in order to service the increasing vessel drafts. Lands suggested for retention to meet terminal and industrial needs are shown in Appendix VIII, Navigation.

Navigation channel improvements would be required in the Duwamish River waterways before 1980 in order to accommodate the growing vessel drafts. Improvements planned for early action would satisfy the foreseeable needs of the projected fleet over the full 50-year planning period. A bulk grain terminal, constructed by the Port of Seattle on Elliott Bay, has access and berthing of unlimited depths to service the ever-increasing drafts of the large bulk carriers. The planned improvements for the Duwamish River waterways are tabulated below:

Navigation Improvements
1970-1980

Channel	Length (Miles)	Depth (Feet)	Investment Costs ($1000)	Average Annual Costs Interest & Amortization ($1000)	O&M ($1000)	Total ($1000)	Benefits ($1000)
West Waterway	1.0	54	245	12	3	15	17
East Waterway	1.2	54	900	42	3	45	60
Duwamish Channel to 1st. Ave. So.	2.6	46	1,715	80	5	85	154
Duwamish 1st Ave. So. to 8th Ave. So.	0.8	30	279	13	0	13	24
8th Ave. So. to Head of Navigation	1.8	20	640	30	3	33	84
Total	7.4		$3,779	$177	$14	$191	$339

During this period a tentative schedule of development calls for construction of three small boat harbors. One located at Des Moines was completed in 1970 and the other two are in the study stage and would be the subject of a comprehensive small boat harbor study proposed for the Seattle Harbor by the Port of Seattle and the city of Seattle. The two sites for purposes of the navigation study were selected for construction in Elliott Bay. One at Pier 54 would primarily be a summer moorage facility, and the other an expansion of the existing Seacrest Marina. Approximately 2,100 wet moorages are included in the Comprehensive Plan as compared to the need during this period for 5,200 moorages. The difference is assumed, for purpose of this study, to be met by further private investment in marina facilities. The construction costs and average annual costs and benefits of the small boat harbor projects tentatively scheduled for construction by 1980 are:

Small Boat Harbor Projects
1970-1980

Location	Wet Moorages	Investment Costs ($1000)	Average Annual[1] Costs ($1000)	Average Annual[1] Benefits ($1000)
Elliott Bay– Pier 54	290	500	37	54
Des Moines	670	1,340	96	125
Seacrest Marina Addition	1,140	2,299	147	212
Total	2,100	$4,139	$280	$391

[1] General navigation facilities costs and benefits only based on 50-year economic life amortized at a 4-5/8% interest rate. Total pleasure boat facilities costs and benefits included with Recreation.

1980-2000—Significant increases in small boat harbor developments are forecast for this period with over 10,000 wet moorages to be provided. The scheduling of small boat harbors constructed during this period depends upon local interest, availability of funds, and other factors. The potential small boat harbor sites shown in the Navigation Appendix would be fully occupied by the year 2000. Further developments for public moorage facilities would require site locations in adjacent basins or greater use of dry moorages than has been indicated as desirable by pleasure boaters. Consequently, no further navigation investments are planned after the year 2000. The public small boat harbor projects tentatively scheduled for this period are:

Small Boat Harbor Projects
1980-2000

Location	Wet Moorages	Investment Costs ($1000)
Wells Point–Edmonds	2,000	4,000
Golden Gardens–North	1,450	2,900
Fort Lawton–North	1,140	2,280
Fort Lawton–South	3,520	7,196
Elliott Bay–Magnolia Bluff	1,910	3,820
Totals	10,020	$20,196

Power

The electrical energy requirements of the Cedar-Green Basins are satisfied by the Northwest Regional Power System, with only a minor amount of power produced within the Basins. Seattle City Light operates the only hydro-electric plant in the Basins at Cedar Falls. Several thermal-electric plants are located in Seattle, and are used as standby or intermittent electric power producers. Appendix IX, Power, forecasts the availability of adequate power from existing sources to satisfy Area needs up to 1980. However, increased power generation would be necessary from local plants to meet the 2000 and 2020 loads.

Only one hydro-electric development project is under active consideration. An increase in power production from the existing generating facilities at Cedar Falls is considered possible from increased storage at Chester Morse Lake. Additional storage at Chester Morse Lake by 1980 is planned to satisfy the needs of flood control and fish. Studies have not been performed on the possible power benefits to be derived from this project. Detailed engineering and economic studies are required to determine the exact features and operation of the project and benefits resulting from optimum use. Flood control and low flow augmentation benefits used in this study for the Chester Morse Lake project would be revised by the more detailed project studies which would include a full evaluation of power and municipal and industrial water supply benefits.

Base-load nuclear-electric generating plants are anticipated at a number of sites within the Puget Sound Area. Exact locations of these plants have not been set, except in a few instances. The Cedar-Green Basins would probably not receive consideration for site selection due to environmental constraints. However, oil or gas-fueled steam electric plants may be located within the Basins to meet the Area's short-time peaking power requirements. Proposed development of any plant would require that adverse impacts on the environment be considered and the means provided to lessen these impacts and mitigate their effects when specific project studies are undertaken. Thermal-power generation is discussed further under the Puget Sound Area.

Flood Control

The flood plain of the Cedar River is subject to frequent flooding with the Cedar River being an uncontrolled stream except for incidental flood control storage at Chester Morse Lake, bank stabilization works, and the improved channel just upstream from Renton to the mouth. Average annual flood damages are estimated to be $117,000 with most of this damage occurring to buildings and equipment. Residential and industrial developments are rapidly encroaching upon the flood plain area below the town of Maple Valley. For this reason, future flood damages are expected to increase significantly over the present level. Optimum development of the flood plain for residential and industrial use would require at least a 100-year level of flood protection.

The only flood problems located along the Sammamish River consist of minor inundation of low agricultural lands, as the channel improvement project constructed in 1964 by the Corps of Engineers in cooperation with King County has generally solved the flood control problem in the Sammamish Basin. However, the minor flooding that does occur, presently estimated to average $5,000 annually, could become a problem if new home sites are developed in

the localized areas of flooding. The Comprehensive Plan relies upon land use zoning to control developments in the Sammamish River flood plain, providing for retention of the flood plain of the Sammamish River as open space to be used for agricultural and recreational purposes such as parks and golf courses.

With completion of the Howard A. Hanson Dam storage project and levee, bank stabilization and other protective works in the Green River Valley, flooding has been reduced to back-up from local inflow. The storage project is capable of reducing flood discharges at Auburn to 12,000 cfs for floods with a recurrence interval in excess of once in 100 years. As levees below Auburn would be overtopped at 12,000 cfs, maximum flow has been temporarily reduced to 10,000 cfs during high water. The effect of this measure is to lessen the amount of storage available for very large floods. Discharge from drainage projects under construction could amount to 2,000 to 4,000 cfs, necessitating a hazardous future reduction in releases from Howard Hanson Dam unless channel and levee improvements are carried out. Average annual flood damages to agricultural lands and industrial and residential developments that are rapidly encroaching upon the flood plain, resulting mainly from local inflow problems, are estimated to be $325,000. Most of the flood plain from Auburn downstream is expected to become industrialized and urbanized.

Elements of the Comprehensive Plan, discussed by time periods below, would reduce flood damages in the Cedar and Green River Basins. Flood protection objectives defined in Appendix XII, Flood Control, are met by the structural elements in this Plan. These objectives have been defined in terms of flood frequency, with industrial and urban lands within the Basin recommended for a 100-year level of flood protection, agricultural lands requiring at least a 25-year level of flood protection, and lands in the flood plain to be used for parks, golf courses, and general recreation requiring a level of flood protection of 10 to 15 years.

1970-1980—A multiple-purpose storage project on the Cedar River at Chester Morse Lake is planned for construction prior to 1980 in order to provide flood protection for the Cedar River flood plain. This project would provide 50,000 acre-feet of flood control storage and in conjunction with subsequent levees and channel work from river mile 4.5 to about 17.5 would provide protection against floods having a recurrence interval in excess of once every 100 years. The existing banks in this reach are over-topped about every year. The 100-year level of flood protection to be provided for Cedar River flood plain would enable full realization of the economic potential of this land.

Preliminary analysis indicates flood control as one of the purposes to justify the Chester Morse project, with construction costs allocated for this purpose estimated at $4,740,000 compared to a total project cost of $5,610,000, making the average annual costs for flood control approximately $263,000 including $41,000 for operation and maintenance, with benefits estimated at $298,000.

A levee improvement project is planned for early action along both banks of the Green River below Auburn. The existing levees would be set back, and the channel widened as required to contain the controlled release from Howard A. Hanson Dam and inflow resulting from interior drainage pumping plants. These plants are proposed for construction prior to 1980. The levee and channel improvements are estimated to cost $12,000,000, with average annual costs of $601,000, including $10,000 for operation and maintenance compared to average annual benefits of $723,000. No additional major flood control measures would be required in the Green River Valley after 1980. The additional capacity provided by the Comprehensive Plan in conjunction with the interior drainage project would provide protection against main-stem floods with a recurrence interval in excess of 100 years. The Soil Conservation Service, in cooperation with local interests, is planning two drainage and flood control projects by the authority of Public Law 566. The project on the east side of the Green River extends primarily from Kent to a pumping plant at the mouth of the Black River in Renton. The project on the west side extends from Auburn to the head of navigation, with the main pumping plant at the mouth of Hill Creek. These projects would provide 58 miles of new and improved drainage channels, complete with outlet works and public plants, and provide 100-year protection from internal flooding. The combined capacity of the floodgates is 5,200 cfs and that of the pumping plants 4,000 cfs.

Flood plain management costs for this period are estimated at $147,000. The tabulation below summarizes the early action flood control programs and projects for the Cedar-Green Basins.

1980-2000—During this period completion of the Comprehensive Plan for a 100-year level of flood control of the Cedar River is scheduled with construction of levees along the river from river mile 4.5 to about 17.5 near Maple Valley. The levee work is estimated to cost $1,300,000.

Continuation of flood plain management in all Basins is planned for the local tributaries to the Cedar, Sammamish and Green Rivers at an estimated cost of $240,000 for the twenty-year period. Land use control in the Sammamish River flood plain would preclude the necessity for further structural measures along that stream.

2000-2020—Continuation of flood plain management in all basins is planned at an estimated cost of $240,000 over the twenty-year period.

Flood Control Element	Effective Flood Control Storage (Ac.Ft.)	River Mile	Height Of Dam (Ft.)	Design Capacity (cfs)	Invest. Costs ($1000)	Average Annual[1] Costs: Interest & Amort. ($1000)	O&M ($1000)	Total ($1000)	Benefits ($1000)
Flood Control Storage Projects									
Chester Morse Lake	50,000	83	80		4,740	222	41	263	298
Channel and Levee Construction				3/					
Levees downstream of Auburn					12,000	591	10	601	723
Subtotal					$16,740	$813	$51	$864	$1,021
Flood Plain Management					147[2]				47
Total					$16,887				$1,068

[1] Allocated flood control costs and benefits for storage projects.

[2] Cumulative program costs for the period.

3/ Flood carrying capacity of channel would be designed to accommodate 12,000 plus local inflow.

Watershed Management

Watershed management needs in the Basins would be satisfied by the progressive development of eight small watershed projects and the continuation and acceleration of land treatment practices. These small watershed projects are for floodwater damage prevention, rehabilitation and protection, and water management, and would make areas of the flood plain suitable for more efficient agricultural use. The watershed management projects included in the Comprehensive Plan are viewed as complimentary to the existing and proposed major flood control projects also contained within the Plan. A number of measures made possible by structural works of improvement are recommended for implementation, including seeding of improved grasses and legumes, growing of cover crops, drainage development, and forest management practices. A continuing investment is required, both public and private, to insure protection of the water and related land. This investment would be in the form of financial assistance, technical assistance, research, education and information. New installations, upgrading of existing facilities and improvements, or more intense application of land management practices would be required for flood protection, water management, and watershed rehabilitation and protection. Management practices and measures in this area are of a recurring nature, requiring new installations, reconstruction and rehabilitation to retain their effectiveness, which is presently estimated at 65 percent. The efficiency is expected to improve as co-dependent measures, primarily consisting of maintenance and rehabilitation of existing facilities, are installed and put into practice.

Federal and State land administrative agencies are responsible for the installation of those measures on land assigned to their management, while initiative of the individual property owner is required for installation of practices on lands in private ownership. Various Federal agencies and the State have programs of technical and financial assistance for individuals, local organizations, and sub-divisions of government, including King County Soil and Water Conservation District and Snohomish County Soil and Water Conservation District. The schedule of watershed

management projects and programs provided for in the Comprehensive Plan is discussed by periods:

1970-1980—Several projects are planned for initiation prior to 1980 in order to remedy existing floodwater and drainage problems. The following are descriptions of projects planned for early action.

Swamp, Bear, and North Creek Watershed—This watershed discharges into the Sammamish River near Bothell. Urbanization is well along on Swamp Creek and is beginning to develop on North and Bear Creeks. The watershed originally had a full forest cover. However, repeated cuttings and suburban development has reduced the timber to a few isolated tracts. The watershed is described in detail in Appendix XIV, Watershed Management.

The works of improvement would consist of 24 miles of improved and stabilized channel and two water control structures providing 5,963 acres of flood water protection and 5,826 acres of drainage improvement. The project installation cost is estimated at $1,165,000, of which the Federal share is $815,000 and the local share is $329,000. Benefits would result from damage reduction and drainage. To achieve these benefits, local interests would be required to install necessary land treatment measures for erosion and flood management controls costing approximately $277,000, drainage measures estimated at $939,000, and forest protection and management practices costing $422,000, for a total of $1,638,000. The total cost of installing the structural and land treatment measures is $2,803,000. The projects' average annual benefits of $134,600 are compared with average annual costs of $63,500, including $9,000 for operation and maintenance.

Evans Creek Watershed—This watershed outlets into the Sammamish River near Redmond, and drains a forested area of about 45 square miles located north and east of Redmond and Lake Sammamish. The flood plain near Redmond, where most of the cropland is located, is broad and nearly level, but in the upper reaches of the stream, the valley floor is relatively narrow and winding. Approximately two-thirds of the watershed is forested, with most of the area having been cut over several times, and urbanization progressing rapidly throughout the watershed. This trend is expected to continue as Seattle and adjoining areas are within easy commuting distances. The project is designed for flood prevention of agricultural and urban areas and water management on agricultural lands, including improvement works consisting of 16 miles of stabilized channel and two floodwater retarding structures for flood control and recreation, providing 3,348 acres of flood protection and 3,620 acres of water management improvements. The installation cost is estimated to be $1,015,000, with the Federal share being $713,000 and the local share $302,000. Benefits would result from damage reduction and drainage. To help achieve these benefits local interests should install necessary land treatment measures for erosion control and flood management, costing approximately $295,000, drainage measures at an approximate cost of $710,000, and forest protection and management practices at $385,900, for a total of $1,392,000. The total cost of installing the structural measures and the land treatment measures is estimated at $2,406,400. The project's average annual benefits of $107,200 are compared with average annual costs of $55,400, including $7,900 for operation and maintenance.

Programs tabulated below include the complementary features to the projects discussed above and other on-farm and urban on-site practices required in the Basins. Non-Federal costs include on-going development costs with redirection and acceleration to meet needs by time periods. Total costs are shown.

Watershed Management Practices
1970-1980

Program	Area (acres)	Cost ($1000)	Program	Area (acres)	Cost ($1000)
Cedar River Basin			Green River Basin		
Technical assistance and management	167,935		Technical assistance and management	271,382	
Federal, regular		4,446	Federal, regular		7,020
Federal, accelerated		1,329	Federal, accelerated		--
Subtotal		$ 5,775	Subtotal		$ 7,020
Installation of practices (non-Federal)			Installation of practices (non-Federal)		
State and corporate		3,763	State and corporate		3,079
Land treatment	101,537	1,352	Land treatment	151,110	2,806
Water management	3,250	930	Water management		
Urban drainage	103,197	139,316	Agricultural	7,447	2,159
Subtotal		$145,361	Urban	44,262	59,754
Total		$151,136	Subtotal		$ 67,078
			Total		$ 74,818

1980-2000—The programs and projects scheduled for this period are tabulated below, with estimated installation costs:

Watershed Management Practices
1980-2000

Program	Area (acres)	Cost ($1000)
Cedar River Basin		
Technical assistance and management	127,760	
Federal, regular		7,667
Federal, accelerated		1,329
Subtotal		$ 8,996
Installation of practices (non-Federal)		
State and corporate		5,018
Land treatment	61,362	1,432
Water management		
Agricultural	2,167	660
Urban	100,162	135,219
Subtotal		$142,329
Total		$151,325

Program	Area (acres)	Cost ($1000)
Green River Basin		
Technical assistance and management	259,183	
Federal, regular		12,239
Federal, accelerated		443
Subtotal		$ 12,682
Installation of practices (non-Federal)		
State and corporate		4,106
Land treatment	138,911	2,779
Water management		
Agricultural	4,964	1,413
Urban	42,960	57,996
Subtotal		$ 66,314
Total		$ 78,976

Project	Area (acres)	Structural Measures Installation Costs ($1000)
Cedar River Basin		
Lake Washington	82,496	520
Sammamish River	101,509	2,710
Cedar River	114,743	580
Total	298,748	$ 3,810

Project	Area (acres)	Structural Measures Installation Costs ($1000)
Green River Basin		
Upper Green River	200,358	1,700
Total Project		$1,700

2000-2020—The projects and programs recommended for implementation during this period are shown in the following:

Watershed Management Practices
2000-2020

Program	Area (acres)	Cost ($1000)	Program	Area (acres)	Cost ($1000)
Cedar River Basin			Green River Basin		
Technical assistance			Technical assistance		
and management	65,278		and management	210,050	
Federal, regular		7,661	Federal, regular		12,235
Federal, accelerated		443	Federal, accelerated		443
Subtotal		$ 8,104	Subtotal		$ 12,678
Installation of practices			Installation of practices		
(non-Federal)			(non-Federal)		
State and corporate		5,018	State and corporate		4,106
Land treatment	7,500	900	Land treatment	89,778	2,108
Water management			Water management		
Agricultural	1,806	1,671	Agricultural	7,000	2,244
Urban	100,162	135,219	Urban	42,960	57,996
Subtotal		$142,808	Subtotal		$ 66,454
Total		$150,912	Total		$ 79,132

Project	Area (acres)	Structural Measures Installation Costs ($1000)	Project	Area (acres	Structural Measures Installation Costs ($1000)
Cedar River Basin			Green River Basin		
Upper West Slope			Lakota-Des Moines	16,550	100
Seattle	37,256	100			
Total		$100	Total		$100

Recreation

With the significant increase in the population of the Seattle metropolitan area, the provision of sufficient facilities to satisfy outdoor recreation demands has become a serious problem. Recreation demand is increasing at a faster rate than supply. Although natural resources within the Cedar-Green Basins are abundant, inadequate facilities and other constraints currently prevent proper utilization of the resources for recreation. A need exists for the preservation and greater public accessibility to many natural attractions in the Cedar-Green Basins, including the shorelines of Puget Sound, Lake Washington, Lake Sammamish, and a 12-mile section of the Green River Gorge from the town of Kanasket to the Kummer Bridge. The many miles of shoreline on the Cedar and Green Rivers should be available to meet the public outdoor recreation needs. Comprehensive land use planning is required in order to guide urban development so that the environmental quality needs of the Basins' population are met.

Two large municipal watersheds within the Basins are now restricted from public recreation use. These watersheds contain 240,000 acres, representing 34 percent of the total Basins' land area. Both watersheds possess significant recreation attractions for camping, picnicking, hunting, and other outdoor activities. Although the current needs for public recreation are not considered sufficient to justify the need for opening up the watersheds, ultimate access to the public for limited recreation activities may be required. These watersheds are viewed as reserves for future recreation use when the demand has been demonstrated and the means of payment for required water treatment facilities is resolved.

Public access to and use of the shorelines and waters within or near the Seattle metropolitan areas is severely restricted by industrial and residential developments, roads and railroads. The demand for marine facilities requires that careful attention be given to future shoreline use of Puget Sound and the bodies of fresh water within the Basins. About 240 publicly-administered developed outdoor recreation areas exist within the Basins. In addition to the developed sites, there are over 90,000 acres of publicly-administered undeveloped Class III general recreation lands. These include much of the land lying in the Seattle and Tacoma municipal watersheds. The State shorelands along the Sammamish, Cedar, and Green Rivers, with better access, could be utilized for hiking, picnicking, and camping. Much of the outdoor recreation needs for picnicking and camping can be met on existing public land. However, the large demand for recreation facilities in and adjacent to the Seattle metropolitan area can only be met through the acquisition of additional private lands. The two military bases in Seattle, Fort Lawton and Sand Point Naval Air Station, are waterfront lands that present an unusual potential for satisfaction of recreation needs. If these lands are declared surplus by the Federal Government, they should be made available for public use.

The broad recreation goal is to promote well-planned development and protection of existing resources, and to provide opportunities for the satisfaction of present and future outdoor recreation demands. Based on Federal ownership of land, plans and programs of recreation suppliers, expected population concentrations, as well as outdoor recreation needs, the assumption is made that the Federal agencies would provide 5 percent of the water-related

opportunities, while the State, County and local agencies, and private interests would supply 20, 45 and 30 percent of the demand respectively. The recreation development as provided for in the Comprehensive Plan, is intended to be compatible with the State of Washington Recreation Plan.

Additional facilities and acquisition and development of land and water areas are required in order to satisfy the above demand for water-related outdoor recreation. These specifc land and water area needs are stated in the following tabulation:

Recreation Land and Water Requirements
1960-2020

		1960		1980		2000		2020	
Activity	Unit	Land	Water	Land	Water	Land	Water	Land	Water
Swimming,									
Beach Area	Acres	0	0	0	0	0	0	103	12
Pools	Sq.Ft.	282,500	140,100	642,200	319,100	1,329,200	663,100	2,567,200	1,290,100
Boating, Sailing,	Acres	0	0	120	31,828	355	151,828	815	391,322
& Water Skiing								2,455	--
Camping	Acres	215	--	555	--	1,255	--		
Picnicking	Acres	194	--	489	--	984	--	1,980	--
Hiking	Miles	0	--	127	--	397	--	791	--

1970-1980–Satisfaction of urgently needed marine-oriented recreation is called for by the construction of public small boat harbors along the shoreline of Puget Sound as discussed under Navigation, with private investment in marina facilities also viewed as necessary to meet wet and dry moorage needs. Improvement and further development of recreation facilities at the 240 publicly-administered outdoor recreation areas within the Basins, along with development of portions of the 90,000 acres of publicly-administered undeveloped Class III general recreation lands, is planned during this period. Over fifty recreation sites are scheduled for improvement or development by 1980.

Designation of a network of scenic roads to provide travel links between recreation attractions would enhance driving-for-pleasure and sight-seeing opportunities within the Basins. Where practical, hiking and riding trails should also be developed within the corridor of scenic roads. A safe public-use easement over and adjacent to the railroad tracks paralleling the shoreline north of the Lake Washington Ship Canal should be investigated. Scenic access easements should be acquired along rivers and streams throughout the Basins to insure that greenbelts are provided within areas which are presently urbanized and those destined for residential development. Preservation of the natural flood plain along the Sammamish River as open space is recommended, consistent with the portion of the Comprehensive Plan discussed under Flood Control. Portions of the Cedar River should also be investigated for this purpose. With the accelerating residential developments in the Cedar River flood plain, opportunities for public access are rapidly being lost. Therefore, proper land use zoning as an element in flood plain management is viewed as essential to insure that these lands would be retained as open space.

The Comprehensive Plan supports the current programs being carried for development and acquisi-

tion of recreation areas and for the establishment of a waterfront boulevard within the city of Seattle. This boulevard would cover 16 miles of Elliott Bay waterfront, from the northern boundary of Fort Lawton to the southern boundary of Lincoln Park. Parks and other recreation and tourist attractions would be provided along the boulevard. A park along the Sammamish River is another element of the planned program. The port facilities along Elliott Bay should be constructed with consideration being given to aesthetics and public enjoyment.

The Comprehensive Plan endorses the provision for 8 acres of land for greenbelt parkway and visitor facilities in the planned development of a grain terminal facility by the Port of Seattle. Other developments along the Puget Sound shoreline, including a fishing pier and a public tower for viewing port activity, also are examples of recognition by the Port of Seattle of the need to satisfy environmental quality considerations.

A State system is suggested to protect the important recreation rivers or river segments for public use. A study is recommended of the Sammamish, Cedar and Green Rivers for portions which may qualify for protection. The Green River Gorge should be set aside for public use and development as a unique area, having outstanding attributes of scenic pleasure and natural wonders. Retention of outstanding natural areas and historical and archeological sites identified in Appendix X, Recreation, for the Cedar-Green Basins would not conflict with other elements of the Comprehensive Plan and are included for inspirational and educational purposes and general enjoyment of the people. Investments for recreation facilities are tabulated below for the various water-related improvements.

Outdoor Recreation Improvements
1970-1980

Feature	Investment Costs ($1000)	Average Annual Costs: Interest & Amortization ($1000)	Average Annual Costs: O&M ($1000)	Average Annual Costs: Total ($1000)	Average Annual Benefits ($1000)
Campgrounds	7,700				
Picnic Areas	2,030				
Trails	762				
Swimming Pools	7,975				
Boating Facilities	10,615				
Planning & Design	7,288				
Land Acquisition	17,985				
Total	$54,425	$2,545	$1,247	$3,792	$4,560

1980-2000–Further expansion and development of public recreation areas in and around Seattle and throughout the entire Cedar-Green Basins is planned. Full utilization of the potential sites for small boat harbors is projected. Land use management programs, begun prior to 1980, would be continued to ensure that greenbelts are retained for public benefit. With the exception of swimming pools which are needed in urban areas, existing waters in the Cedar-Green Basins and in the adjacent West Sound Basins will satisfy water-based recreation demands until the year 1990. After that date, additional surface waters may be needed at locations within easy access from Seattle. Multiple-purpose water impoundments, including those now in the watersheds, should be considered for the satisfaction of boating, sailing, water skiing, and other natural water-use activities. However, proper safeguards to public health of the water consumer would be required as well as a clear demonstration of need and economic justification. Planned improvements and developments within this period are estimated at $49,500,000 and costs for land acquisition including better zones, at $20,500,000 with about 40 recreation sites planned for expansion or new development.

2000-2020–During this period, more extensive development of public land is anticipated. The assumption is made that lands now in public ownership would be retained and additional private lands in and around the Seattle metropolitan area acquired to satisfy marine and urban recreational needs. In this way, with proper public land management and the use of waterfront access leases, large-scale acquisition of private lands is not foreseen as being necessary to meet the future recreational needs.

Total recreational development costs during this period are estimated at $64,300,000 and $40,300,000 for land acquisition, including buffer zones with 30 recreation sites planned for expansion or new development.

Fish and Wildlife

The Cedar-Green Basins offer numerous opportunities for projects and programs that, if implemented, would maintain and increase fish and shellfish production. That portion of the Comprehensive Plan dealing with fish and wildlife is discussed by the following time periods:

1970-1980–Important measures for the enhancement and preservation of fish, planned for early action, include the release of minimum flows in the Cedar River of 100 cfs from June through August, as measured at the Renton gauge. Local inflows between this point and the Landsburg Diversion Dam would require augmentation by releases from the Chester Morse storage project (see Flood Control) during low flow years. The tentative investment costs allocated to fish on the basis of low flow augmentation benefits are estimated at $870,000 for the Chester Morse project, with average annual costs of $49,000 including $8,000 for operation and maintenance. The flood control benefits which would accrue to fish in the Cedar River as a result of the flood control storage at Chester Morse Lake are included with average annual low flow augmentation benefits, with total benefits estimated at $55,400 resulting from an additional 186,000 pounds of commercial fish and 500 user-days of sport fishing.

Construction of a fish ladder at the city of Seattle Landsburg Dam is recommended for further consideration to enable use of 11 miles of natural spawning channel. This measure could result in increased production of 81,000 sockeye, 4,000 coho, and 600 chinook salmon annually, and providing $130,500 in annual benefits to the commercial fishery and $22,400 to sport fishery in the Puget Sound Area. Cost of this improvement is estimated at $75,000. Possible hazards to public health which may be introduced by allowing fish passage at the Landsburg Dam preclude this measure from being part of the Comprehensive Plan at this time. Further studies are required to evaluate the possible health hazard to determine if a water treatment plant would in fact be required if anadromous fish were allowed to migrate upstream of the dam and to evaluate the economic feasibility of this measure.

In lieu of the fish passage facility the Plan provides for increased salmon and steelhead production through expanded artificial propagation facilities.

A tentative additional 40 cfs of low flow augmentation is recommended for the Green River for a total of 150 cfs to be released at Howard Hanson Dam during the period of June through September. The exact amount of additional flow for fish use is recommended for determination by further detailed studies. The amount of increased conservation storage to be allocated between municipal and industrial water supply for the city of Tacoma and for fish use will be determined in part by the benefits to be derived from each and the willingness of sponsors to accept responsibility for payment of associated costs.

Other major facilities contained in the Comprehensive Plan for preservation and enhancement of fish include the acquisition and development of an access at each of 21 lakes, construction of a spawning channel in the Cedar River, and a steelhead rearing pond complex on the Green River, with a game fish hatchery also being constructed prior to 1980 to stock lakes and streams. These measures would cost $2,872,000 and would provide 186,100 angler-days of increased fishing. During this period, a total of 50 miles of stream bank access on the Cedar and Green Rivers and 10 miles on tributaries would be acquired at an estimated $1,535,000 which would increase fishing by 10,000 angler-days annually. Lake access areas are designated in Appendix XI. A boat launch with fishing access is proposed for the Lake Washington Ship Canal immediately downstream from the Chittenden Locks and at four other salt water areas at an estimated $60,000 benefiting 23,000 angler-days annually. Public access at all significant lakes and key salt water estuarine and stream segments within the Basins will be assured by planned development during this period. A spawning channel and propagation sites

are suggested for Rock and Madsen Creeks in the Cedar Basin.

During this period, programs are planned for the enhancement of marine fish which would include the creation of additional production habitat through selective placement of rock jetties or submerged scrap automobiles. Shellfish production and harvest also would benefit from the construction of beach break-waters where strong currents now limit the production. Studies and implementation of techniques to eliminate or control natural predators and the alteration of environment to promote and increase natural production is recommended. Shellfish and marine fish features have not been evaluated in terms of costs or benefits, but are included in the Comprehensive Plan for further study by the State fish and game agencies.

An improvement is planned for fish passage at the Chittenden Locks with construction of a second fish ladder adjacent to the small lock wall at the spillway near the exit of the salt water drain. Modification of the salt water drain and construction of the second fish ladder are expected to cost an estimated $500,000 with an average annual benefit of $40,000 estimated for anadromous fish, derived from large runs of sockeye salmon entering the Cedar River system and other anadromous fish gaining access from Puget Sound through the Lake Washington Ship Canal. Although large numbers of the salmon use the navigation locks during the late summer and early fall when little or no water is spilling at the spillway, significant numbers of salmon are attracted to the turbulent waters of the salt water drain, where they are temporarily held at the base of the spillway, thereby delaying the migration to spawning areas. This, in the opinion of the State fish biologists, reduces the potential production of salmon.

Wildlife measures included in the Comprehensive Plan for early action are a study to determine the feasibility of eventual controlled recreational use of the Seattle and Tacoma watersheds with determination of requirements for water treatment, cost of treatment and economic feasibility of the use, and an expansion of an existing game farm to produce 5,000 more pheasants to satisfy hunter needs in the Basins. Band-tailed pigeon concentration areas would be acquired and ten sites for pheasant release and hunting would be leased and developed for this purpose. These measures are estimated to $75,000 and would increase hunter use by 28,100 days annually.

The projects and programs for fish and wildlife preservation and enhancement are tabulated below:

Fish and Wildlife
Projects and Programs
1970-1980

Projects

(1) Lease and development of 10 sites for pheasant releases and hunting.

(2) Acquisition of band-tailed pigeon concentration areas.

(3) Expansion of existing game facilities to produce 5,000 more birds

(4) Acquisition and development of access to 21 lakes.

(5) Construction of trout hatchery to stock lakes.

(6) Construction of spawning channel–Cedar River.

(7) Construction of steelhead rearing pond on Green River.

(8) Acquisition and development of access on 50 miles of main river and 10 miles of tributaries–Green River.

(9) Construction of trout hatchery to stock streams.

(10) Acquisition and development of 5 salt water access areas.

(11) Operation of Howard Hanson Reservoir for additional conservation storage for fish use.

(12) Low flow augmentation and flood control–Cedar River (Chester Morse Lake storage).

(13) Modification of salt water drain and constructing fish ladder (H.M. Chittenden Locks).

Programs

(1) Development of education programs regarding value of wildlife.

(2) Development of cooperative programs with land owners to preserve wildlife habitat and assure access.

(3) Development of compatible forest-wildlife management techniques.

(4) Development of program for recreational use of closed watersheds.

(5) Development of new fish toxicants and lake fertilization techniques.

(6) Development of program for stimulation of interest in spiny-rayed fishing.

(7) Development of fish disease control program.

(8) Locate, survey and mark boundaries of all State owned 2nd class tidelands.

(9) An inventory of shellfish stocks and recreational use of tidelands.

Fish and Wildlife
Project and Program Costs[1]
1970-1980

Feature	Investment Costs ($1000)	Average Annual Costs: Interest & Amortization ($1000)	O&M ($1000)	Total ($1000)	Benefits ($1000)
Projects	5,937	$278	$209	$487	1,081
Programs	440[2]				687[3]
Total	$6,377				$1,768

[1] Includes allocated fishery enhancement costs from multiple-purpose storage projects.

[2] Cumulative program costs for the period.

[3] Some of program benefits included in with project benefits.

1980-2000–Fish programs planned for this period include the study of fish passage facilities at the Howard A. Hanson project with the construction of trapping facilities and a truck and haul arrangement required to transport adult salmon and steelhead into the upper watershed above the project. Problems associated with passage of downstream migrants must be investigated before this project can be implemented. Possible changes in water quality which could result from anadromous fish spawning also must be considered. The Comprehensive Plan does, however, recommend that further study be given to this proposal. A significant increase in the production of coho salmon and the development of a sockeye salmon run in the Green River may be possible from this project, as discussed in Appendix XI, Fish and Wildlife.

Clearance and improvement of two miles of Burns and Crisp Creeks and six miles of channel in three other streams are called for during this period. The channel clearance and improvement projects will increase commercial fish production by a total of 3,300 fish and produce 500 average annual sport user-days. A one-mile spawning channel in the Cedar or Green Rivers is recommended as a project for implementation prior to the year 2000 and will result in the increase in commercial harvest of 92,700 fish and 2,150 user-days of sport fishing.

A continuation of the game fish and wildlife programs, projects implemented during the period prior to 1980, is recommended together with a research for enhancement of the game fishery in Lake Washington and Lake Sammamish, and other new projects as required. A total investment cost of $8,517,900 is estimated for the game fish and wildlife measures to be implemented during this period, as shown in the following tabulation:

Fish and Wildlife
Projects and Programs
1980-2000

Projects	Investment Costs
Improve habitat on 22 streams–51 miles	151,500
Clear and improve Burns and Crisp Creeks–2 miles	7,600
Clear channel on 3 streams–6 miles	1,100
Construct 1 mile of spawning channel	700,000
Other projects for fish and game	7,055,700
Total	$7,915,900

Program	Investment Costs
Continuation of fish and wildlife programs	$602,000

2000-2020—During this period, construction of four additional salmon hatcheries or their equivalent, is recommended, which would provide 140,400 commercial fish and satisfy 28,000 user-days of sport fishing needs annually. Thirty-five acres of rearing facilities projects recommended to be constructed before 2020 would produce 7,000 additional sport fishermen days each year. A total investment cost of $17,292,000 is estimated for game fish and wildlife programs and measures during this period. The fish and game projects recommended for implementation prior to 2020 are tabulated below:

Fish and Wildlife
Projects and Programs
2000-2020

Projects	Investment Costs
Construct 4 hatcheries or the equivalent	$4,080,000
Develop 35 acres of rearing facilities	192,500
Develop 1 mile of spawning channel	700,000
Other projects for fish and game	11,544,500
Total	$16,517,000

Program	Investment Costs
Continuation of fish and wildlife programs	$775,500

COST-BENEFIT SUMMARY

The investment costs by resource function are shown in Tables 8-20 and 8-21 for the Cedar-Green Basins with the costs distributed between Federal, State, local and private interests. Average annual costs and benefits also are shown for projects recommended for implementation prior to 1980. The investment costs include cumulative annual program costs for each of the three planning periods as shown in Table 8-20 and capital project costs as shown in Table 8-21. Interest and amortization costs are based on a 100-year economic life with appropriate allowances made for major replacements. An interest rate of 4-5/8 percent was used in the economic analysis. All measures proposed for early action are justified on the basis of tangible benefits. Benefits for municipal and industrial water supply and water quality improvement were assumed equal to annual charges.

Investment costs were allocated to the various interests on the basis of available information including the technical appendices multiple-purpose project studies, and experience at similar projects.

TABLE 8-20. Program investment costs[1] ($1000), Cedar-Green Basins

Feature	Private	Government			Total
		Local	State	Federal	
		1970-1980			
Water Quality Control	580	580	1,570	670	3,400
Flood Control		84	24	39	147
Watershed Management	113,160	98,881	1,095	12,818	225,954
Fish and Wildlife			440		440
Subtotal	$ 113,740	$ 99,545	$ 3,129	$ 13,527	$ 229,941
		1980-2000			
Water Quality Control	812	812	2,252	964	4,840
Flood Control		168	48	24	240
Watershed Management	112,147	94,955	1,460	21,739	230,301
Fish and Wildlife			602		602
Subtotal	$ 112,959	$ 95,935	$ 4,362	$ 22,727	$ 235,983
		2000-2020			
Water Quality Control	892	892	2,476	1,060	5,320
Flood Control		168	48	24	240
Watershed Management	111,252	96,548	1,460	20,784	230,044
Fish and Wildlife			776		776
Subtotal	$ 112,144	$ 97,608	$ 4,760	$ 21,868	$ 236,380
Total	$ 338,843	$ 293,088	$ 12,251	$ 58,122	$ 702,304

1 Cumulative annual program costs over the period.

TABLE 8-21. **Project investment costs[1] and cost-benefit summary, Cedar-Green Basins ($1000)**

Feature	Investment Costs					Annual Costs			Annual Benefits	
		Government								
	Private	Local	State	Federal	Total	Interest & Amortization[2]	Operation & Maintenance	Total	Total	Net
1970-1980										
M&I Water Supply	2,704	19,000			21,704	1,172	2,163	3,335	3,335	0
Irrigation					0	0	0	0	0	0
Water Quality Control		55,500	27,750	30,600	113,850	5,323	1,447	6,770	6,770	0
Navigation[3]		2,212		1,567	3,779	177	14	191	339	148
Power						0	0	0	0	0
Flood Control[4]		1,200		15,540	16,740	815	49	864	1,021	157
Watershed Mgmt.[5]		654		1,526	2,180	102	17	119	242	123
Recreation	16,328	24,490	10,885	2,722	54,425	2,550	1,242	3,792	4,560	768
Fish & Wildlife[4]			5,067	870	5,937	278	209	487	1,081	594
Subtotal	$ 19,032	$103,056	$ 43,702	$ 52,825	$ 218,615	$ 10,417	$ 5,141	$ 15,558	$ 17,348	$ 1,790
1980-2000										
M&I Water Supply	10,140	64,380			74,520					
Irrigation	55				55					
Water Quality Control		135,000	67,500	73,300	275,800					
Navigation[3]					0					
Flood Control		130		1,170	1,300					
Watershed Mgmt.[5]		1,653		3,857	5,510					
Recreation	21,000	31,500	14,000	3,500	70,000					
Fish and Wildlife			7,916		7,916					
Subtotal	$ 31,195	$ 232,663	$ 89,416	$ 81,827	$ 435,101					
2000-2020										
M&I Water Supply	22,087	65,760			87,847					
Irrigation	55				55					
Water Quality Control		117,000	58,500	61,500	237,000					
Navigation[3]					0					
Flood Control					0					
Watershed Mgmt.[5]		60		140	200					
Recreation	31,380	47,070	20,920	5,230	104,600					
Fish & Wildlife			16,517		16,517					
Subtotal	$ 53,522	$ 229,890	$ 95,937	$ 66,870	$ 446,219					
Total	$ 103,749	$ 565,609	$ 229,055	$ 201,522	$ 1,099,935					

1 Capital project costs.

2 Of initial investment and major replacement.

3 Costs and benefits for pleasure boating moorage included with recreation.

4 Allocated costs for Chester Morse Lake multiple-purpose project.

5 Installation of structural measures only.

Sequence of Development

The projects and programs of the Comprehensive Plan are summarized in Table 8-22 by period. The project numbers identify features on Figure 8-5.

TABLE 8-22. Future projects and programs, Cedar-Green Basins

PROJECTS PRIOR TO 1980

Municipal and Industrial Water Supply

1.* Small and rural community ground water development.
2.* Self-supplied industry surface water development.
3. Construction of diversion and transmission facilities at North Fork Tolt River–Seattle.
4. Expansion of existing system–Renton.
5. Expansion of existing system–Kent.
6. Expansion of existing system–Auburn.
6a. Expansion of transmission facilities from Green River–Tacoma (for Puyallup Basin).

Water Quality Control

7.* Expansion of Metro waste collection and treatment system.
8. Improvement of outfall at Alki sewerage treatment plant.
9. Improvement of outfall at Southwest Suburban Sewer District, Salmon Creek plant.
10. Improvement of outfall at Sylvia Pines Sewer District.

Navigation

11. Channel improvement–West Waterway.
12. Channel improvement–East Waterway.
13. Channel improvement–Duwamish Channel to 1st Avenue South.
14. Channel improvement–Duwamish 1st Avenue South to 8th Avenue South.
15. Channel improvement–Duwamish 8th Avenue South to head of navigation.
16. Small boat harbor development–Elliott–Pier 54.
17. Small boat harbor development–Des Moines.
18. Small boat harbor expansion–Seacrest Marina addition.

Flood Control

19. Flood control storage at Chester Morse Lake multiple-purpose project–Cedar River.
20. Levee and channel improvements downstream from Auburn–Green River.

Watershed Management

21. Small watershed multiple-purpose project–Swamp, Bear, and North Creeks.
22. Small watershed multiple-purpose project–Evans Creek.

Recreation

23. Development of six recreation sites along saltwater shoreline.
24. Development of one recreation site.
25. Development of two recreation sites.
26. Development of four recreation sites.
27. Development of three recreation sites along Lake Union and Lake Washington Ship Canal.
28. Development of three recreation sites along Sammamish River.
29. Development of seven recreation sites along shoreline of Lake Washington.
30. Development of three recreation sites along Cedar River from mouth to Landsburg Dam.
31. Development of five recreation sites along Green River from mouth to city of Tacoma water supply diversion dam.

Fish and Wildlife

32.* Lease and development of 10 sites for pheasant releases and hunting.
33.* Acquisition of band-tailed pigeon concentration areas.
34.* Expansion of existing game farm facilities to produce 5,000 more birds.
35.* Acquisition and development of access to 21 lakes.
36.* Construction of trout hatchery.
37.* Construction of spawning channel–Cedar River.
38.* Construction of steelhead rearing pond–Green River.
39.* Acquisition and development of access on 50 miles of main river and 10 miles of tributaries–Green River.
40.* Acquisition and development of five saltwater access areas.
41. Operate Howard Hanson project to provide additional low flow augmentation for fish–Green River.
19. Low flow augmentation and flood control from Chester Morse Lake multiple-purpose project–Cedar River.
42. Modification of salt water drain and construction of fish ladder at H.M. Chittenden Locks–Lake Washington Ship Canal.

PROGRAMS PRIOR TO 1980

Water Quality Control

a. Expand water quality surveillance stations at salt and fresh water locations monitor, and control treatment, evaluate and prepare comprehensive sewerage plan for the Basins.

Flood Control

b. Establish and administer county-wide flood plain zoning measures under flood plain management program.

*Project not shown on Figure 8-5.

Watershed Management

c. Provide technical assistance and management for State and Federal lands.

d. Provide technical assistance for on-farm and other practices.

Fish and Wildlife

e. Develop lake fertilization techniques.

f. Make wildlife population analysis and timberland management practices studies, develop habitat improvement techniques and an education program on proper game hunting concepts, and begin a program with land owners for game habitat retention and hunter access.

g. Develop fish disease controls and new toxicants.

h. Conduct cross-sectional stream surveys to determine minimum and optimum streamflows for fish.

i. Locate, survey, and mark boundaries of all State-owned second class tidelands in the Basins. Take steps to reserve all such lands for public use except as required for specific circumstances.

j. Perform an inventory of shellfish stocks and recreational use of tidelands.

PROJECTS 1980-2000

Municipal and Industrial Water Supply

43.* Self-supplied industry surface water development.

44.* Water system expansion—Renton, Kent and Auburn.

45. Construction of additional storage in Cedar River watershed and install third pipeline—Seattle.

46. Increase storage capacity of North Fork Snoqualmie River project and install transmission lines—Seattle.

Irrigation

47.* Installation of individual farm irrigation pumping and sprinkler system (private)—Green River.

Water Quality Control

48.* Expansion of waste treatment and interception facilities for municipalities, industry and recreation development.

Navigation

49. Small boat harbor development—Well's Point—Edmonds.

50. Small boat harbor development—Golden Gardens—North.

51. Small boat harbor development—Fort Lawton—North.

52. Small boat harbor development—Fort Lawton—South.

53. Small boat harbor development—Elliott Bay—Magnolia Bluff.

Flood Control

54. Construction of levees and improvement of channel from R.M. 4.5- to R.M. 17.5—Cedar River.

Watershed Management

55. Small watershed multiple-purpose project—Lake Washington.

56. Small watershed multiple-purpose project—Sammamish River.

57. Small watershed multiple-purpose project-Cedar River.

58. Small watershed multiple-purpose project—Upper Green River.

Recreation

59. Development of four recreation sites along saltwater shoreline.

60. Development of one recreation site.

61. Development of two recreation sites.

62. Development of four recreation sites.

63. Development of one recreation site along Lake Union or Lake Washington Ship Canal.

64. Development of one recreation site along Sammamish River.

65. Development of two recreation sites along shoreline of Lake Washington.

66. Development of four recreation sites along Cedar River from mouth to Landsburg Dam.

67. Development of five recreation sites along Green River from mouth to city of Tacoma water supply diversion dam.

Fish and Wildlife

68.* Improve 51 miles of habitat on 22 streams.

69. Clear and improve two miles of channel Burns and Crisp Creeks.

70.* Clear six miles of channel on three streams.

71.* Construct one mile of spawning channel.

PROGRAMS 1980-2000

Water Quality Control

k. Continue water quality surveillance programs.

Flood Control

l. Continue flood plain management programs.

Watershed Management

m. Continue technical assistance and management for State and Federal lands.

n. Continue technical assistance for on-farm and other practices.

Fish and Wildlife

o. Continue fish and wildlife programs.

PROJECTS 2000-2020

Municipal and Industrial Water Supply

72.* Self-supplied industry surface water development.

*Project not shown on Figure 8-5.

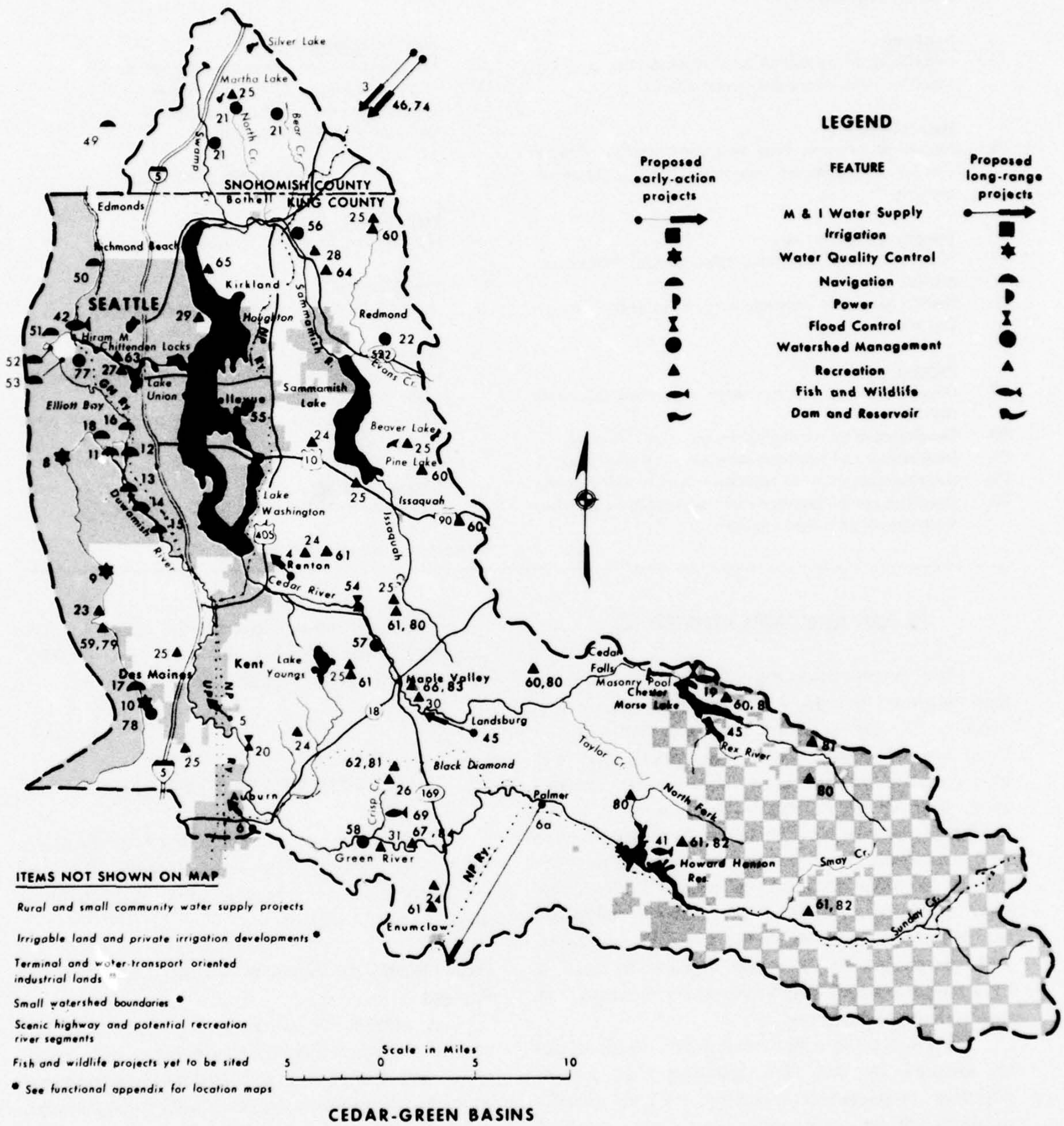


FIGURE 8-5. Comprehensive Plan elements

TABLE 8-22. Cont.

73. Water system expansion–Renton, Kent and Auburn.
74. Development of North Fork Skykomish River for water supply–Seattle.

Irrigation

75.* Installation of individual farm irrigation pumping and sprinkler system (private)–Green River.

Water Quality

76.* Expansion of waste treatment and interception facilities for municipalities, industry and recreation development.

Watershed Management

77. Small watershed multiple-purpose project–West Slope Seattle.
78. Small watershed multiple-purpose project–Lakota–Des Moines.

Recreation

79. Development of two recreation sites along salt water shoreline.
80. Development of one recreation site in this vicinity.
81. Development of two recreation sites in this vicinity.
82. Development of three recreation sites in this vicinity.
83. Development of five recreation sites along Cedar River from mouth to Landsburg Dam.
84. Development of five recreation sites along Green River from mouth to city of Tacoma water supply diversion dam.

Fish and Wildlife

85.* Construct 4 hatcheries or the equivalent.
86.* Develop 35 acres of rearing facilities.
87.* Develop one mile of spawning channel.
88.* Other projects for fish and game.

PROGRAMS 2000-2020

Water Quality Control

p. Continue water quality surveillance programs.

Flood Control

q. Continue flood plain management programs.

Watershed Management

r. Continue technical assistance and management for State and Federal lands.
s. Continue technical assistance for on-farm and other practices.

Fish and Wildlife

t. Continuation of fish and wildlife programs.

*Project not shown on Figure 8-5.

PLAN ACCOMPLISHMENTS

The accomplishments of the Comprehensive Plan are shown in Table 8-23. All of the quantifiable needs of the Basins are met by the Plan with the exception of urban water management and wet moorages for pleasure craft. Urban water management needs would be met by the year 2020. In the preceding time periods a residual is shown as intensive land use would be required to achieve a minimum density in order to facilitate project undertaking. Over 6,000 of the unmet wet moorage needs are planned for satisfaction in the Cedar-Green Basins, with the balance of the unmet needs to be satisfied by a proportionately greater use of dry moorage than now is desired by boaters.

The sport and commercial fishery needs would be satisfied by the Plan assuming that present pollution problems are corrected. As only specific solutions for the early action period were provided for wildlife needs, subsequent periods were assumed to be satisfied by projects and programs that would be developed later. A reduction in hunter success is anticipated with a willingness of hunters to accept a lower success ratio necessary in order to meet projected needs. Hunters also may be required to utilize hunting areas in Eastern Washington.

ALTERNATIVE ELEMENTS

Alternative measures considered to those elements contained in the Comprehensive Plan and the reasons for not adopting these alternatives are discussed in this section.

Alternatives to Chester Morse Lake Storage Project

A number of alternatives to upstream flood control storage at Chester Morse Lake were investigated including levees and channel improvements, which by themselves were not found to be economically feasible, due to right-of-way costs. Flood plain evacuation was found not to be economically feasible because of the magnitude of the existing improvements and the facilities that would require relocation. Floodproofing of existing build-

TABLE 8-23. Comprehensive Plan accomplishments, Cedar-Green Basins

Feature	Units	To 1980 Needs	To 1980 Accomp.	To 1980 Residual	To 2000 Needs	To 2000 Accomp.	To 2000 Residual	To 2020 Needs	To 2020 Accomp.	To 2020 Residual
M&I Water Supply	Mgd	188.3	188.3	0	418.5	418.5	0	957.1	957.1	0
Irrigation	1000 Acre-ft.	0	0	0	1	1	0	2	2	0
Water Quality Control										
Waste	1000 Pop. Equiv.	1,787	1,787	0	3,414	3,414	0	6,086	6,086	0
Navigation										
Commercial	1000 Short Tons	9,200	9,200	0	19,800	19,800	0	37,200	37,200	0
Pleasure	Wet Moorages	5,220	2,100	3,120[2]	15,500	15,240	260[3]	35,500	15,240	20,260
Power[1]										
Flood Control	$1000 Damage Reduction	780	740	40	1,700	1,680	20	3,740	3,700	40
Watershed Management										
Flood Prevention	1000 Acres	50.4	50.4	0	50.4	50.4	0	50.4	50.4	0
Watershed Protection & Rehabilitation[5]	1000 Acres	704.2	704.2	0	704.2	704.2	0	704.2	704.2	0
Water Management[4]										
Agricultural	1000 Acres	10.6	10.6	0	17.8	17.8	0	23.7	23.7	0
Urban	1000 Acres	264.9	147.5	117.4	317.2	290.7	26.5	433.7	433.7	0
Recreation	1000 User-days	5,700	5,700	0	14,400	14,400	0	29,900	29,900	0
Fish and Wildlife										
Sport										
Fishing	1000 User-days	506	506	0	1,266	1,266	0	2,516	2,516	0
Hunting	1000 User-days	50	50	0	116	116	0	156	156	0
Commercial Fishing	1000 Pounds	692	692	0	2,186	2,186	0	4,922	4,922	0

[1] Power needs were projected for the Puget Sound Area only.

[2] Residual wet moorage needs assumed to be satisfied by private developments.

[3] Residual needs of 6,280 wet moorages provided for in Snohomish Basin.

[4] Needs and accomplishments are cumulative.

[5] The necessary level of management is assumed to be established throughout the Basins, otherwise some residual could occur.

ings was also evaluated as an alternative to major flood protective works for reducing present and future flood damages. About $70,000, which is approximately 60 percent of the estimated $117,000 average flood damages, occurs to buildings. A percentage of these buildings are wood frame construction, and flood proofing would require structural treatment that is not economically feasible. This alternative would not meet the present or future needs for optimum development and utilization of the Cedar Basin flood plain. Diversion of the flood waters, by tunneling or other means, into adjacent basins would just transfer flood damages from the Cedar to these Basins. Alternative storage sites at Rex River and upstream on the main stem of the Cedar also were considered. However, the Chester Morse Lake is considered to be the most economical site for storage development within the Cedar Basin. The low flow augmentation needs of fish in the Cedar River can only be supplied from storage releases at Chester Morse Lake, unless the city of Seattle is forced to reduce its current withdrawals of water from the Cedar. This alternative is not considered practical, as the city has a large investment in the existing water supply system and claims a vested right to current water use. Future municipal and industrial water supply needs for the city, associated with the construction of the third pipeline, can be met in part from the storage at Chester Morse Lake.

Alternatives to Levees on the Cedar River

Levees are required to compliment storage at Chester Morse Lake in order to provide the 100-year flood protection that would eventually be required for the entire Cedar River flood plain to meet growing urbanization and development. There are no feasible storage sites that could be constructed downstream on Cedar River or on tributaries to the Cedar River below Chester Morse Lake that would provide an equivalent protection at less cost than would construction of levees. A storage site on Taylor Creek is considered to be suitable for single-purpose, short duration, flood control storage only, and therefore is not viewed as a viable alternative. Levee construction along the Cedar River can be done commensurate with urban development occuring in the flood plain.

Alternatives to North Fork Tolt River Storage Project

The only alternatives to development by the city of Seattle of the Tolt River resource in 1975

would be further development on the Cedar River sooner than had been planned with construction of the third pipeline, moved up from 1985 to 1975, or storage projects on the North Fork of the Snoqualmie River or the North Fork of the Skykomish River. Seattle has scheduled the North Fork Tolt project before the third pipeline on the Cedar River as this meets their earlier need for water to the northern end of the city. The North Fork Snoqualmie project would require treatment facilities earlier than anticipated by the city, thereby costing more money than would water from the North Fork of the Tolt. Likewise, the early development of the North Fork of the Skykomish would be a more expensive project than would the North Fork Tolt system.

Alternatives to the Development of the North Fork Snoqualmie River

This project is planned for development as a multiple-purpose facility and is contained in the Comprehensive Plan for the Snohomish River Basin. At the time the Seattle service area demand requires development of a new facility, the North Fork of the Snoqualmie would be an existing project available for use by the city, and would be the least cost alternative open to the city for further development.

Alternatives to the North Fork of the Skykomish Project

The North Fork of the Skykomish is viewed as the only project that would be feasible at this time for construction to meet the city's long-range water supply needs. Satisfaction of water supply needs by the city from desalinization plants may be possible in the distant future or technological innovations may preclude the necessity for this project.

Alternatives to Levees and Channelization in the Green River

Additional storaged gained by raising Howard A. Hanson Reservoir or by constructing new storage upstream on Sunday and Smay Creeks or at the Weston site on the main stem Green River was considered. However, economic feasibility of such storage was found to be lacking. Diversion of flood waters from the Basin was considered and found to lack economic feasibility.

Alternatives to Recreation and Fish and Wildlife Measures Proposed in the Technical Appendices

As limited information was provided with regard to specific locations of recreation areas, no analysis could be made to determine whether sites proposed for development were necessarily the most economical that could be provided to achieve a given amount of recreation benefits. All fish and wildlife measures recommended in Appendix XI, Fish and Wildlife, were included in the Comprehensive Plan except for the fish ladder at Landsburg Dam. Further studies are required as to the possible adverse impacts of spawned fish on water quality before this element can be included in the Plan. As limited information was available in terms of alternatives for satisfying fish and wildlife needs, those measures recommended in Appendix XI, Fish and Wildlife, were generally adopted and included in the Comprehensive Plan for implementation prior to 1980. All fish and wildlife measures proposed for after 1980 also were included in the Comprehensive Plan with some reservations made about the construction of a fish passage facility at the Howard Hanson project. This project requires further study.

Alternatives to Ground Water Development by Renton, Kent, and Auburn

Full utilization of ground water was chosen in the Comprehensive Plan as being the least expensive alternative presented in Appendix VI, Municipal and Industrial Water Supply, for satisfying the future water supply needs of Renton, Kent, and Auburn. However, the ground water resource may be limited and further investigation should be made of the resource in order to determine if the long-range plan as presented can, in fact, be implemented. If the ground water resource is not adequate to serve the projected needs of these cities, provision has been made by the city of Seattle Water Department for supplying the needs of Renton and Kent and by the city of Tacoma for Auburn.

Alternatives to Water Quality Control of Lake Washington by Minimum Cedar River Inflows

Water quality needs associated with operation of the salt water drain at the Chittenden Locks can be

met, in most years, from inflows supplemented by Lake Washington storage. Recent construction of a salt water barrier has reduced the fresh water requirement for flushing of the salt water drain by a minimum of 30 percent. Depending on future levels of lock use and diversion of water from the Cedar River, refined operating procedures of the salt water drain, together with the salt water barrier, are sufficient to meet the water quality standards established for Lake Washington and the Ship Canal during most years. Non-storage alternatives available to satisfy possible water quality problems during extreme low inflow years include drawing down Lake Washington below minimum desired levels, use of a mechanical lift device for pleasure craft passage at the locks, use of a thrift lock, and curtailment or shutdown of the lock itself, if warranted.

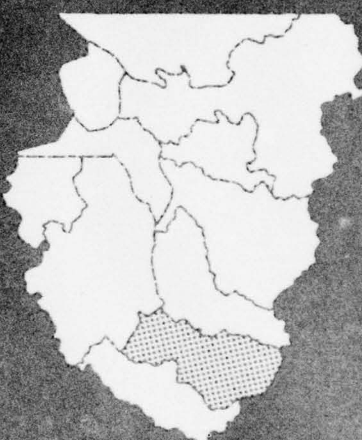
Alternatives to Seattle Supplying Water to Bellevue

Consideration was given to development of an independent water supply system for the city of Bellevue and other suburban communities located east of Lake Washington as an alternative to continuing to obtain water wholesale from Seattle. A consultant for the city has investigated the feasibility of developing a water supply from Lake Calligan located in the Cascade Mountains, approximately 9 miles northeast of North Bend. The city of Bellevue proposes construction of a 36-inch supply line which would parallel an existing pipeline of the Seattle Water Department. The Seattle Water Department now serves a population of nearly 1,000,000 and has published a long-range plan of supply for its service area which includes Bellevue.

The city of Bellevue (1970 population 58,000) and surrounding vicinity have been included as part of the Seattle service area because of the economies of scale associated with water supply development by large water purveyors, such as the cities of Seattle, Tacoma, and Everett. These should provide the least cost source of water for smaller communities other than ground water or diversion from nearby streams. Also, the development by large water purveyors is considered to be in the overall best interest of environmental quality as a minimum number of possibly disruptive impoundments and structures are placed on streams, rivers and lakes. More of these resources are left in their natural state for the satisfaction of environmental needs than if each individual water district sought to satisfy its own needs through resource development.

Equitable wholesale water rates are necessary, however, to insure that cost savings are passed onto all those served by the large water purveyors. Without an equitable rate structure, suburban communities may, in fact, be able to develop their own water supplies at less cost.

Puyallup Basin



PUYALLUP BASIN

DESCRIPTION OF BASIN

GENERAL

The Puyallup Basin comprises an area of 1,217 square miles of land and inland water, and 37 square miles of salt water, a total area of 1,254 square miles. There are 48 miles of salt water shoreline. A major portion of the Basin is in Pierce County; the remainder in King County. The principal stream is the Puyallup River, having a drainage area of 972 square miles, and emptying into Commencement Bay, an arm of Puget Sound.

Of the eleven Basins in the Puget Sound Area, the Puyallup ranks fifth in size and sixth in runoff, with an average of 2,700,000 acre-feet flowing into salt water annually. The Puyallup River runoff, measured at Puyallup, has averaged 2,490,000 acre-feet annually. Runoff from its major tributary, the White River, measured near Buckley, has averaged 1,080,000 acre-feet annually.

The orographic lifting of the moist maritime air on the windward foothill slopes and higher elevations of the Cascades results in an annual precipitation varying from 35 inches at Tacoma to 100 inches at Paradise Inn on Mount Rainier. Average annual snowfall ranges from 5.4 inches at the Puyallup Experiment Station to 582 inches at the Paradise Ranger Station.

Streamflow characteristics and other related hydrologic data for the Basin are discussed in detail in Appendix III, Hydrology and Natural Environment. The physiographic characteristics and soil properties contributing to drainage are discussed in more detail in Appendix V, Water-Related Land Resources.

PRESENT SITUATION

Local Economy

Approximately 350,000 people reside in the Basin. Tacoma is the largest city and the hub of Basin commercial and industrial activity. Farmland in the Puyallup River valley is rapidly being absorbed for industrial, commercial and residential development. Major city and Basin populations are summarized in Table 9-1.

TABLE 9-1. Historical population, Puyallup Basin

	1940	1950	1960	1967
Puyallup Basin	174,600	264,600	308,400	349,800
Principal cities and towns:				
Tacoma	109,410	143,700	148,000	156,000
Puyallup	7,890	10,010	12,060	14,200
Sumner	2,140	2,820	3,160	3,950
Buckley	1,170	2,700	3,540	3,650
Milton	670	1,370	2,220	2,600
Orting	1,210	1,300	1,520	1,600

Source: Appendix V, Economic Environment, Appendix V, Water-Related Land Resources.

The most rapidly expanding sector of the Basin economy is heavy industry, including an oil refinery, an aluminum reduction plant, chemical products plants, a ferroalloy plant, and industries related to aircraft manufacturing. Considerable dredge and fill activities have been pursued in the Puyallup River tideflats which are the location of Tacoma's major port and industrial area. Puyallup, Sumner and Buckley are experiencing light industrial expansion.

Agricultural activities in the Basin are located on the rich, alluvial lands downstream from Orting and Auburn on the Puyallup and White Rivers, respectively. Agriculture production, as of 1964, had a value of $13,364,000. In recent years some of the specialty crops such as bulbs, flower plants, shrubs and herbs have superseded dairying as the most important agriculture product in the Basin. Poultry, berry and vegetable production also are important with most of the vegetable produce being shipped to Tacoma, Seattle, and other Puget Sound cities.

The Basin's forests are a prime resource which help sustain several large sawmills and wood pulp producing mills in the Basin. The excellent harbor at Tacoma, with practically unrestricted approach depths and large land transportation and back-up terminal area, serving both foreign and domestic deep and shallow draft commerce, is important to the Puget Sound Area economy.

Land Use

Within the Puyallup Basin is a total of 759,000 acres of land. The present land use is summarized in Table 9-2 and shown on Figure 9-1.

TABLE 9-2. Present land use, Puyallup Basin

Land Use	Acres	Percent
Forest[1]	593,300	78.1
Range	5,700	0.8
Crop	36,900	4.9
Rural nonagricultural	25,700	3.4
Intensive (built-up)	97,400	12.8
Total	759,000	100.0

[1] Includes open land normally associated with forested areas.

Source: Appendix V, Water-Related Land Resources.

Forests occupy 78 percent of the land. Agriculture (crop and range), accounting for 5.7 percent of the land use, is primarily on the productive alluvial lowlands. Intensively used land encompasses residential, industrial, public and semi-public uses and amounts to 12.8 percent of the total land area. Intensive use is tabulated by acres in Appendix V, Water-Related Land Resources, as follows: railroads, 2,636; highways, 4,920; airports, 3,270; and urban (built-up), 86,620 for a total of about 97,000 acres. The areas of intensive development are in the vicinity of Tacoma, Puyallup, Sumner, Buckley, Milton, Orting and the military reservations; McChord Air Force Base and Fort Lewis.

Land ownership including fresh water areas, is shown in Table 9-3.

TABLE 9-3. Land ownership, Puyallup Basin

Ownership	Percent
Private	25
Private corporate	31
Federal	39
State	3
Local government	2
Total	100

Source: Appendix V, Water-Related Land Resources.

PROJECTED ECONOMY AND LAND USE

Local Economy

In Table 9-4 is a forecast of population, employment and gross regional product for the Central Division (Snohomish, King, Pierce and Kitsap Counties) and projected population for the Puyallup Basin with the forecast translated into average annual growth trends.

TABLE 9-4. Economic projections, Puyallup Basin

					Average Annual Growth Trends (Percent)			
	1963	1980	2000	2020	1963 to 1980	1980 to 2000	2000 to 2020	1963 to 2020
Central Division								
Population (1000's)	1,600	2,400	3,900	6,200	2.4	2.4	2.4	2.4
Employment (1000's)	600	800	1,400	2,200	2.4	2.4	2.4	2.4
Gross Regional Product (1,000,000's 1963 $)	5,172	10,000	24,569	62,061	3.9	4.6	4.7	4.4
Puyallup Basin								
Population (1000's)	324.5	449.8	700.0	1,107.5	1.9	2.4	2.4	2.3

Source: Appendix IV, Economic Environment, Appendix V, Water-Related Land Resources.

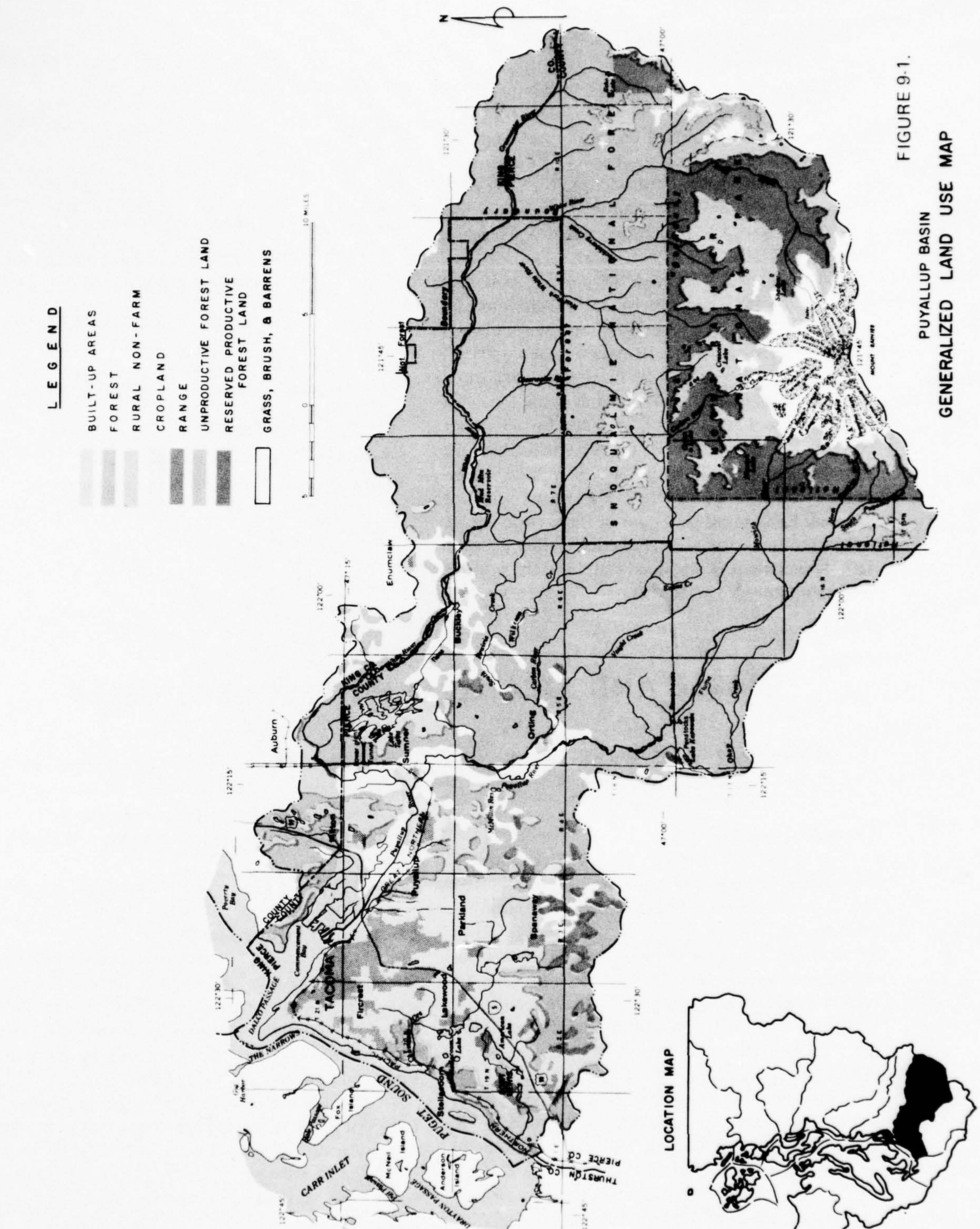


FIGURE 9-1.
PUYALLUP BASIN
GENERALIZED LAND USE MAP

Future Land Use

The projected Basin land use shown on Figure 9-2 is compared in Table 9-5 with present land use. This land use pattern, based on the construction of a cross-sound bridge and a bridge between the mainland and southern Whidbey Island, projects for the Puyallup Basin an intensive land use density increase from the present 3.33 persons per acre to 8.0 persons per acre by 2020.

To support an increase in population of 3.2 times the present population by 2020, there would be a need to increase the intensively-used land by about 41,000 acres or 1.4 times its present amount. These lands would come primarily from forest and rural nonfarm lands. Forest land would decrease by about 3 percent and rural nonfarm land by about 83 percent. By the year 2020, the western half of the Puyallup Basin would be a part of a large metropolitan band stretching from Everett to south of Tacoma. Early implementation of flood plain zoning would provide a means of restricting further unnecessary development of the flood plain, thereby insuring retention of needed greenbelts.

TABLE 9-5. Present and projected land use,[1] Puyallup Basin (acres)[2]

Land Use	1967	1980	2000	2020
Forest	593,300	589,800	583,500	576,000
Range	5,700	5,700	5,500	5,200
Cropland	36,900	36,500	35,000	33,700
Rural nonfarm	35,700	20,000	14,000	5,900
Intensive	97,400	107,000	121,000	138,200
Total	759,000	759,000	759,000	759,000
Population	349.8	449.8	700.0	1,107.5
Density[3]	3.33	4.2	5.8	8.0

1 Alternative land use pattern C_2, see Puget Sound Area.

2 Figures rounded to nearest hundred.

3 Persons per intensive land use acre.

Source: Appendix V, Water-Related Land Resources.

WATER AND RELATED LAND RESOURCE NEEDS

MUNICIPAL AND INDUSTRIAL WATER SUPPLY

General

In 1965, approximately 100 mgd was supplied from surface and ground water sources. Of the 100 mgd approximately 63 mgd had been diverted from the Green River. (In 1968, Tacoma's Green River diversion was operating continuously at or near full capacity, approximately 72 mgd or 113 cfs). Of Tacoma's Green River water, 70 to 75 percent is distributed to industry in and around Tacoma with approximately 20 mgd average to Tacoma municipal distribution and use.

One-third of the present demand is met from within the Basin and generally by ground water source. The city of Tacoma operates a substantial well system consisting of 14 wells with a combined peak capacity of approximately 66 mgd. Tacoma uses this ground water primarily during periods of high turbidity in the Green River. Most of the rural and small community municipal water demands are met by ground water. Several industries have also developed their own supplies from ground water sources.

The 1965 water use is summarized in Table 9-6.

Present and Future Needs

Future needs have been developed under the assumption that the industrial complex along the shores of Commencement Bay and in the lower Puyallup valley would continue to expand with heavy industry, such as pulp and paper, aluminum, petroleum, and food and kindred industries.

The Tacoma system is operating at nearly full capacity. There is an imminent need for the development of future sources of water supply in the Basin.

The projected need for municipal and industrial water supply is shown in Table 9-7.

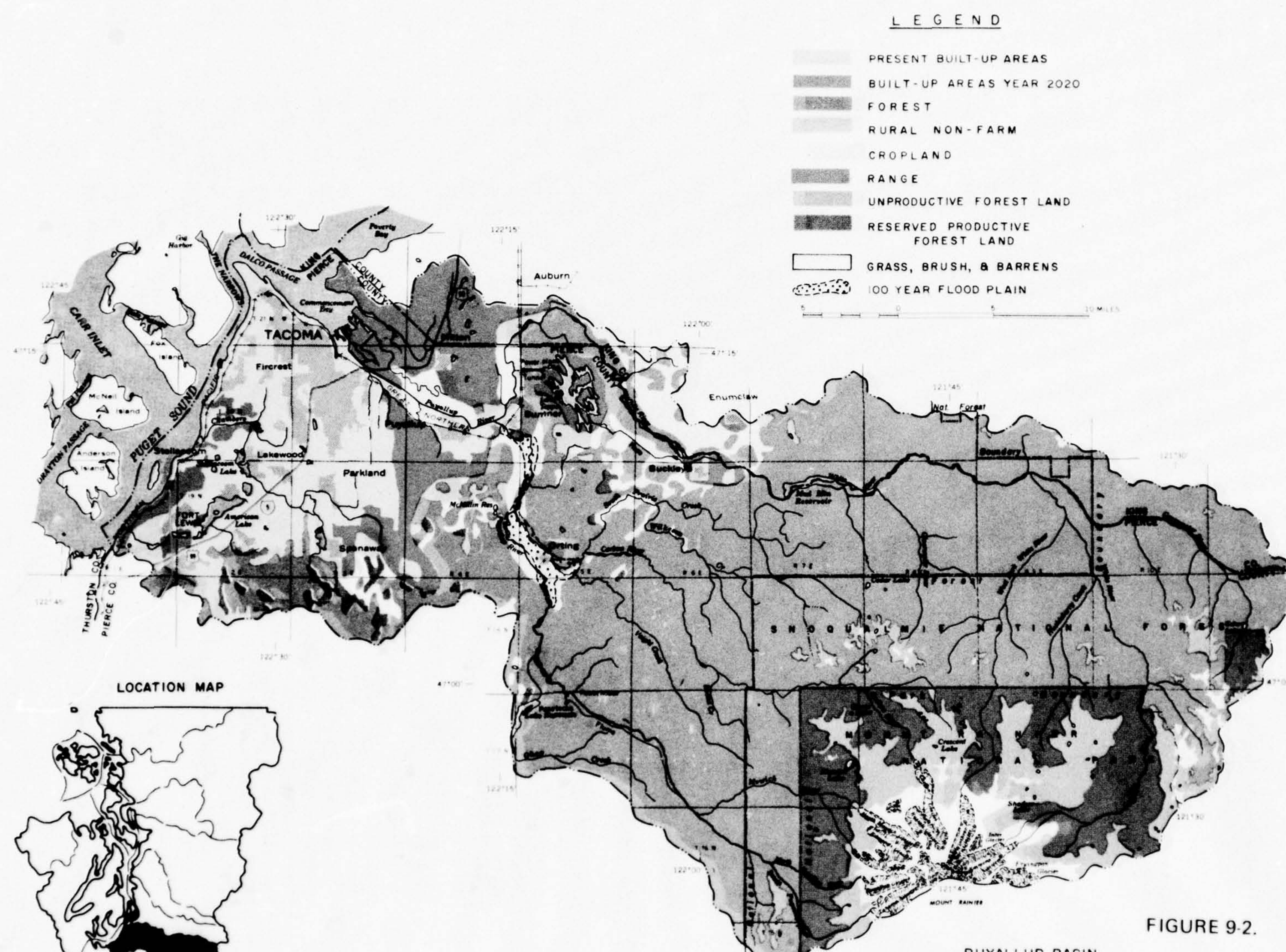


FIGURE 9-2.

PUYALLUP BASIN

GENERALIZED LAND USE MAP

Alternative C2 –2020

TABLE 9-6. Municipal and industrial water use, Puyallup Basin 1965

System	Estimated Population Served	Surface Water Usage (mgd) Average Daily	Maximum Monthly	Maximum Daily	Ground Water Usage (mgd) Average Daily	Maximum Monthly	Maximum Daily
MUNICIPAL USE							
Tacoma	158,000	20.40	26.80	32.80	1.97	60.00	65.00
Fort Lewis	60,000	--	--	--	8.00	15.00	19.70
Lakewood Water District	40,000	--	--	--	3.00	6.00	10.00
Puyallup	15,000	--	--	--	1.80	5.50	9.30
Parkland Light and Water Co.	12,000	--	--	--	0.95	1.07	2.05
Southeast Tacoma Mutual Water Co.	7,500	--	--	--	0.50	0.75	1.50
Buckley	6,000	0.60	0.80	1.00	--	--	--
Milton	4,600	--	--	--	0.44	0.83	1.32
Fircrest	4,350	--	--	--	0.25	0.50	1.00
Sumner	4,000	--	--	--	0.65	0.82	1.00
Bonney Lake	1,800	--	--	--	0.16	0.35	0.40
Steilacoom	1,670	--	--	--	0.20	0.60	1.00
Orting	1,500	--	--	--	0.07	0.12	0.15
Wilkeson W.D.	950	--	--	--	0.09	0.13	0.15
Other rural community systems	27,585	0.67	1.29	1.61	4.31	6.62	8.75
Subtotal	344,455	21.70	28.90	35.40	22.40	98.30	113.30
RURAL-INDIVIDUAL USE	745	0.01	0.02	0.02	0.04	0.06	0.08
INDUSTRIAL USE							
Municipally supplied:							
Tacoma:							
Paper and allied		28.60	31.90	33.30	0.20	3.50	3.70
Food and kindred		1.60	2.00	2.50	0.20	0.30	0.30
Chemicals		5.10	7.38	9.00	0.60	0.82	1.00
Primary metals		3.16	3.45	5.05	0.34	0.45	0.55
Lumber and wood		1.54	2.23	2.70	0.17	0.25	0.30
Stone, clay, glass		0.17	0.36	0.33	0.02	0.04	0.07
Other		0.92	1.50	2.00	0.10	0.15	0.25
Puyallup:							
Food and kindred		--	--	--	0.01	0.02	0.03
Stone, clay, glass		--	--	--	0.12	0.16	0.20
Sumner:							
Paper and allied		--	--	--	0.14	0.60	1.04
Stone, clay, glass		--	--	--	0.08	0.08	0.08
Self-Supplied:							
Paper and allied (Chambers Cr.)		0.30	0.40	0.50	5.20	5.30	5.50
Paper and allied (Sumner)		--	--	--	0.92	1.00	1.10
Primary metals (Kaiser Al.)		--	--	--	2.90	3.00	3.10
Stone, clay, glass		0.09	0.11	0.13	0.30	0.40	0.53
Food and kindred (Sumner)		--	--	--	0.33	0.34	0.34
Subtotal		41.48	49.33	55.81	14.63	16.41	18.09
Total	345,200	63.16	78.24	91.24	37.06	114.81	139.49

Source: Appendix VI, Municipal and Industrial Water Supply.

TABLE 9-7. Projected municipal and industrial water needs, Puyallup Basin

Year	Use	Total (Average Daily M.G.D.)	Total (1000's Acre-Feet Annually)	Net Needs[1] (M.G.D.)	Net Needs[1] (1000's Acre-Feet)
1965	Municipal	44.1	49.4		
	Industrial	56.1	62.8		
	Rural-Individual	0.1	0.1		
	Total	100.3	112.3		
1980	Municipal	86.0	96.3		
	Industrial	100.0	112.0		
	Rural-Individual		--		
	Total	186.0	208.3	85.7	96.0
2000	Municipal	152.3	170.2		
	Industrial	177.2	199.3		
	Rural-Individual	0.1	--		
	Total	328.6	369.5	228.3	257.2
2020	Municipal	266.0	297.9		
	Industrial	280.9	315.9		
	Rural-Individual	0.3	--		
	Total	547.2	613.8	446.9	501.5

[1] Cumulative totals above 1965 use.

Source: Appendix VI, Municipal and Industrial Water Supply.

IRRIGATION

General

There are approximately 1,580 farms in the Puyallup Basin. Approximately 7 percent of these farms had some irrigated cropland in 1964. Farms with irrigated cropland average about 100 acres. Nearly two-thirds of the irrigated cropland is in forage crops and slightly more than half of the remaining cropland is in berry crops. The remaining acreage is occupied by vegetable crops. Approximately 3.7 percent of the total livestock production is attributable to irrigated land.

Excluding approximately 3,700 acres presently irrigated, there are approximately 38,600 acres of potentially irrigable land in the Basin. About 1,460 acres are irrigated along the Puyallup River below Puyallup. A total of 1,350 acres are irrigated in the north-south Puyallup-White River valley above Sumner. On the upper White River near Buckley approximately 280 acres are irrigated. There are 250 acres irrigated in the vicinity of the Carbon River-South Prairie Creek area and 360 acres are scattered at miscellaneous locations throughout the Basin.

There has been no adjudication of the water rights claimed prior to 1917. As of April 30, 1966, 349 permits or certificates had been issued for surface water rights for irrigation. The total maximum diversion to serve these rights is approximately 55 cfs for about 5,000 acres. Ground water irrigation rights as of September 30, 1966, total 57 cfs for approximately 3,000 acres.

Present and Future Needs

The diversion requirement characteristic for the Puyallup Basin is 2.37 acre-feet/acre. The peak farm delivery requirement is 69 acres per cfs and monthly distribution of the irrigation requirement is as follows, expressed in a percentage of annual demand:

May	4%	July	31%	September	14%
June	21%	August	30%		

The total of additional acreage irrigated between now and 2020 is projected to be 10,000 acres. The distribution of these 10,000 acres by time periods is estimated in Table 9-8.

TABLE 9-8. Irrigation present status and projected needs, Puyallup Basin

Year	New Irrigation (acres)	Total Irrigation (acres)	Total Annual Diversion (ac. ft.)	Net Needs[1] (ac. ft.)
1965		3,700	8,000	--
1980	2,500	6,200	14,700	5,900
2000	5,000	11,200	26,500	17,700
2020	2,500	13,700	32,500	23,700

[1] Cumulative annual diversion above 1965 use.

Source: Appendix VII, Irrigation.

WATER QUALITY CONTROL

General

Municipalities and industry in the Puyallup Basin are discharging wastes to rivers and streams equivalent to those from a population of approximately 65,000 people.

The chemical quality of surface water in the Basin is soft and low in dissolved solids, high in dissolved oxygen concentration. The only evidence of any oxygen "sag" is in the Chambers Creek area where in Flett Creek the minimum dissolved oxygen content has dropped to a low of 4.5 ppm.

The sanitary quality of streams in the Basin is highly variable. On the Puyallup River near Orting the coliform bacteria is usually less than 100. However, further downstream at Puyallup, MPN values range from 0 to 24,000. On Boise Creek the MPN count ranges from 37 to 48,000, with occasional maximums as high as 240,000 mpn near Buckley.

Due to the glacial origin of the Basin streams, streamborne sediment is excessive.

Present municipal and industrial waste discharges are shown in Table 9-9.

Present and Future Needs

Attainment of the water quality standards established by State and Federal agencies under the Water Quality Act of 1965 and as stated in the Washington Water Quality Standards is the primary goal in this aspect of the resource. Specific quality objectives for the waters of the Basin are given in Appendix XIII.

City sewage having primary treatment and industrial waste are being discharged into the marine waters of Commencement Bay, the Tacoma Narrows, the Chambers Creek tidal area and along Cormorant Passage. The major portion of these wastes which are 501,000 PE, are discharged into Commencement Bay.

The substantial population and industrial expansion expected in the Basin would intensify existing water quality problems unless given adequate treatment. The projected wasteloading is presented in Table 9-10.

TABLE 9-10. Present and projected raw wasteloadings, Puyallup Basin (1000's PE)

Year	Municipal	Industrial	Recreational	Total	Net Needs[1]
1965	356	458	25	839	676
1980	561	626	39	1,226	1,063
2000	990	1,108	75	2,173	2,013
2020	1,444	1,600	138	3,182	3,019

[1] Cumulative raw wasteload requiring treatment above that receiving treatment in 1965.

Source: Appendix XIII, Water Quality Control.

TABLE 9-9. Summary of municipal and industrial wastes, Puyallup Basin, 1965

Receiving Water	Estimated Population Served	Nonseasonal Untreated Waste PE	Seasonal Untreated Waste PE	Treatment	Nonseasonal Waste Discharge PE	Seasonal Waste Discharge PE
Puyallup River						
Orting	500	600	--	Primary	350	--
Washington Soldiers Home	150	150	--	Primary	120	--
Food processing	--	1,000	--	None	1,000	--
Puyallup	12,000	14,000	14,000	Primary	7,500	10,000
Food processing	--	--	16,000	None	--	16,000
Paper and allied	--	7,000	--	None	7,000	--
Tacoma STP No. 1	160,000	250,000	--	Primary	160,000	--
Food and kindred	--	(63,600)	--	Tacoma	(40,000)	--
Carbon River						
Carbonado	425	500	--	None	500	--
Orting STP No. 2	500	600	--	Primary	400	--
White River						
Paper and allied	--	7,500	--	None	7,500	--
Food and kindred	--	2,000	--	None	2,000	--
Rainier St. School	2,000	2,500	--	Secondary	370	--
Buckley	1,800	2,000	--	Primary	1,300	--
Sumner	3,225	3,900	--	Primary	2,400	--
Food and kindred	--	750	--	None	750	--
Food and kindred	--	--	9,000	Sumner	--	6,000
Boise Creek						
Lumber and wood	--	6,000	--	Pond	6,000	--
Enumclaw	2,400	3,000	--	Secondary	360	--
Puget Sound–Commencement Bay						
Chambers Creek						
Flett Creek						
Food and kindred	--	1,900	--	None	1,900	--
Paper and allied	--	31,200	--	None	31,000	--
Steilacoom	5,000	6,000	--	Primary	4,000	--
Tacoma Western Slopes STP	5,048	6,000	--	Primary	4,000	--
Fort Lewis	50,000	70,000	--	Primary	45,000	--
Hylebos Creek and Waterway						
Naval Reserve Training Center	--	100	--	None	100	--
Food and kindred	--	500	--	None	500	--
City Waterway						
Lumber and wood	--	1,700	--	Primary	1,200	--
Food and kindred	--	1,300	--	None	1,300	--
Non-intercepted outfalls	--	10,000	--	None	10,000	--
North End STP	50,000	60,000	--	Primary	40,000	--
Port Industrial Waterway						
Food and kindred	--	3,600	5,000	None	3,600	5,000
Puyallup Waterway						
Paper and allied	--	294,000	--	None	294,000	--
Wapato Creek and Waterway						
Food and kindred	--	2,300	5,000	None	2,300	5,000
TOTAL	293,000	790,000	49,000	--	636,000	42,000
Municipal	--	355,000	--	--	226,000	--
Industrial	--	435,000	49,000	--	390,000	42,000

Source: Appendix XIII, Water Quality Control.

NAVIGATION

General

In the Puyallup Basin the major portion of the activity in water-oriented commerce and industry is located in the Tacoma area. There are depths in excess of 100 feet offshore along most of the 48 miles of shoreline. However, due to the steep slopes of adjacent land only the shores in Commencement Bay are suitable for major harbor development. The Puyallup River is not navigable for anything other than shallow draft vessels except in the tidal reach at the mouth.

Most of the harbor development existing in Commencement Bay is in the Puyallup River delta on fill from extensive dredging activities. Small boating is active in the marine waters adjacent to the Puyallup Basin.

Present and Future Needs

Based upon projections of growth for the entire study area, the small boat moorage needs and projected waterborne commerce are estimated in Table 9-11.

TABLE 9-11. Projected pleasure boating needs and waterborne commerce, Puyallup Basin

	Small Boat Wet Moorages			Waterborne Commerce (1000's Short Tons)	
Year	Total	Net Needs[1]	Year	Total	Net Needs[2]
1966	2,670	1,322	1963	5,000	--
1980	4,350	3,000	1980	8,700	3,700
2000	8,450	7,100	2000	19,000	14,000
2020	16,400	15,050	2020	22,200	17,200

[1] Cumulative needs above the 1,348 available in 1966.

[2] Cumulative waterborne commerce above total for 1963.

Source: Appendix VIII, Navigation.

The role played by facilities of the Port of Tacoma in the Puyallup Basin is of major significance in the study area. However, the capability to meet the needs of commerce of the Tacoma Port would be exhausted within a relatively few years thus further accommodations for increasing waterborne commerce would necessitate port expansion elsewhere in the Puget Sound Area.

Harbor and channel requirements and terminal/industrial land accommodations are shown in Table 9-12.

TABLE 9-12. Harbor and channel and terminal and water transport-oriented industrial land requirements, Puyallup Basin

	Harbor & Channel Req. (vessel draft in feet)			Terminal and Industrial Land (acres)	
Year	Freighters	Bulk Carriers	Tankers	Total	Net Needs[1]
Present	--	--	--	1,300	--
1980	39	57	98	3,000	1,700
2000	40	71	104	5,000	3,700
2020	40	71	104	5,000	3,700

[1] Cumulative land needed above 1963 use.

Source: Appendix VIII, Navigation.

POWER

General

The two existing hydroelectric power plants are Electron, on the Puyallup River, and on the White River power plant near Sumner. Both of these plants are owned and operated by the Puget Sound Power and Light Company. The diversion dam for the Electron plant creates a reservoir of 120 acre-feet. The Electron plant has an installed capacity of 25,500 kilowatts. The White River plant with an installed capacity of 70,000 kw, utilizes Lake Tapps as a storage reservoir. The city of Tacoma operates two steam electric plants with a combined capacity of 59,000 kilowatts.

Present and Future Needs

The electrical energy needs are expected to grow even faster than the rate of population expansion. Additional power generation and transmission facilities would be required to meet these needs. There are a number of sites in the Basin having a potential for hydroelectric power development. These include pumped-storage sites as well as multiple storage sites where power could be provided as an additional project purpose.

A number of thermal nuclear power plants the Pacific Northwest regional system to meet future needs of the Puget Sound Area. The possibility of a nuclear-fired power plant being located in the Puyallup Basin is unknown at this time. Further location and environmental studies must be conducted before specific sites can be selected. Power needs are discussed further in the Area portion of this Appendix.

FLOOD CONTROL

General

The 18,500-acre flood plain of the Puyallup River is composed of 6,150 acres below Sumner, 10,500 acres from Sumner to 2 miles above Orting, 1,000 acres near South Prairie and 850 acres along the White River. Development in the flood plain include the industrial section of Tacoma, cultivated agricultural lands and related buildings, fruit and vegetable processing and freezing, and meat packing plants in Orting, Auburn, Pacific City, Sumner, Puyallup and Alderton. Flood damages begin when flows in the Puyallup River at Puyallup exceed 25,000 cfs. Average annual flood damages are estimated to be $100,000 and result from damage to agricultural land, farm and residential buildings, commercial enterprises, utilities, roads and flood protective works.

The Puyallup River Basin characteristically has two high water periods. One occurs in the late fall, coinciding with maximum precipitation, and the other coincides with spring snow melting in high areas.

Table 9-13 lists the peak discharges of recent major floods at Puyallup.

TABLE 9-13. Major floods, Puyallup Basin

	Peak Discharge of Puyallup R. at Puyallup (cfs)
29 Jan. 1965	41,500
Nov. 1959	35,600
Dec. 1955	37,600

Source: Appendix XII, Flood Control.

Existing flood control measures include flood forecasting and warning service by the U.S. Weather Bureau; levees on the Puyallup, Carbon and White Rivers; the Mud Mountain Dam flood control project on the White River; channel improvement on the Puyallup River from Auburn to Tacoma; and flood plain management.

The Mud Mountain project provides a high degree of protection to the White River valley and the Puyallup downstream of Sumner. Levees provide protection from normal spring floods which would otherwise severely damage crops. They do not prevent flooding by large spring or winter floods. Overtopping of the levees along the Puyallup River may be expected at intervals of two to 10 years. Levees on the Carbon River may be overtopped at intervals of two years while the levee on the White River may be overtopped at intervals of 10 years.

Flooding is confined largely to the upper flood plain where steep mountain slopes suddenly level off to a relatively flat gradient. Major flooding occurs along the 5-mile reach of the Puyallup upstream from its confluence with the Carbon River. In the lower 4-mile reach of the Carbon River, Orting and vicinity experience minor flooding. Sand and gravel deposited by both rivers reduce the channel capacity of the

Puyallup and contribute to overbank flows. Continuous maintenance is required to retain the minimum channel capacity of the Puyallup in this reach. Present channel capacities are estimated to be 5,000 cfs for the Puyallup and 6,000 cfs for the Carbon River.

Present and Future Needs

The present average annual flood damages of $100,000 occur to agricultural, buildings and equipment, transportation facilities and flood protective works. The trend of development within the Basin is expected to result in future growth of flood damages approximating 3-3/4 percent compounded annually if additional flood control is not provided. Future growth of average annual flood damages are expected to be $151,000 in 1980, $301,000 in 2000 and $602,000 in 2020 as shown in Table 9-14.

TABLE 9-14. Projected flood damage reduction needs,[1] Puyallup Basin

Year	Total ($1000)	Net Needs[2] ($1000)
1966	100	100
1980	151	151
2000	301	301
2020	602	602

[1] Based on 1966 prices and conditions.

[2] Flood damages which would occur without additional measures.

Source: Appendix XII, Flood Control.

The community of Orting suffers frequent flood damages and should be provided with protection against floods which have a recurrence interval of 100 years or greater. Additional flood control is desirable to protect the increasingly valuable agricultural investment and provide for urban and industrial expansion. On the upper reaches of the Puyallup River and tributaries, particularly South Prairie Creek, loss of land through erosion during flood discharges should be prevented. The entire flood plain should be managed to permit only those developments that are consistent with the degree of flood protection provided.

Some small tributaries require some flood protective works such as channel improvements and floodgates to allow these streams to properly discharge flood flows.

WATERSHED MANAGEMENT

General

Watershed management is comprised of structural and nonstructural measures for flood prevention, watershed protection and rehabilitation, and water management on agricultural and urban lands.

Implementation of integrated programs and projects for flood prevention, drainage, erosion prevention, land treatment and rehabilitation, and water management on forest, agricultural and urban lands is required. The execution of integrated programs and projects would meet the primary objectives and enhance water quality improvement, municipal and industrial water, fish and wildlife habitat, recreation and the Basin's general environment.

Present and Future Needs

The needs for watershed management in some instances require practices or measures to be implemented on the same area of land. Many measures and treatments become involved in integrated programs and projects. The broad needs for improved technology programs and projects are given under the Area discussion. The watershed management needs for the Basin are tabulated in Table 9-15.

TABLE 9-15. Total watershed management needs, Puyallup Basin

Year	Flood Prevention[1] (acres)	Watershed Protection and Rehabilitation (acres)	Water Management: Agricultural (acres)	Water Management: Urban (acres)
1980	48,100	759,000	12,000	123,200
2000	48,100	759,000	19,900	123,600
2020	48,100	759,000	26,600	198,500

[1] Includes flooding on main streams but not forested land within flood plain areas.

Source: Appendix XIV, Watershed Management.

RECREATION

General

There are presently 118 publicly-administered outdoor recreation areas in the Basin.

The outdoor recreation demand in the Puyallup Basin was estimated to be more than 16 million activity occasions during 1960. Thirty-seven percent of this demand was for water-related activities.

Present and Future Needs

By the year 2020 a six-fold increase in recreation demand is anticipated. The present and projected recreation needs are given in Table 9-16.

TABLE 9-16. Present and projected water-related recreation demand, Puyallup Basin (1000's recreation days)

Year	Total	Net Needs[1]
1960	2,500	600
1980	5,000	3,100
2000	9,700	7,800
2020	18,000	16,100

[1] Cumulative needs above 1,900,000 recreation days satisfied by existing facilities in 1960.

Source: Appendix X, Recreation.

Reduction of air pollution from industries in the Tacoma area would improve recreation potential. Also, reduction in water pollution in and adjacent to Commencement Bay and improving limited access to shoreline due to the presence of railroad right-of-way would enhance conditions. A stable pool associated with Mud Mountain Reservoir and Lake Tapps would aid recreation.

Fulfillment of the future recreational needs in the Basin is oriented toward development of additional access and not toward creation of new areas of water surface. In addition to indicated needs, urban parks, scenic routes, waterfront access, recreation rivers, special interest areas, interpretive facilities, open spaces, and beaches and trails for activities other than swimming and hiking are necessary to satisfy the recreation and environmental needs of the people.

FISH AND WILDLIFE

General

The Puyallup River is a significant producer of salmon and steelhead.

Accessible stream areas stated to be utilized by anadromous fish include approximately 60 miles of main-stem Puyallup River and its smaller tributaries, 100 miles of main-stem White River and tributaries and more than 56 miles of the Carbon River and its tributaries. Additionally, 24 miles of accessible streams enter Puget Sound independent of the Puyallup River.

Resident game fish also occupy the stream areas previously mentioned in addition to the reaches above any migratory blocks. Non-stream areas occupied include 251 lakes having a total area of 6,170 acres. Present management programs provide stocking of rainbow, summer and winter run steelhead and cutthroat trout, as well as kokanee.

Principal big game species found in the area are black-tailed deer, elk, black bear and mountain goats.

Upland birds are found throughout the lower and middle Puyallup Valley. Waterfowl, once abundant in the lower Puyallup tidelands habitat, have been reduced in numbers, partly due to developmental activity preempting habitat in those areas.

Present and Future Needs

There is a need to retain and expand fishing opportunities for trout, steelhead, salmon and other species in the Puyallup Basin. Similarly there is a need to provide opportunities for hunting commensurate with population growth. The projected fishing and hunting needs for the Basin are shown in Table 9-17.

TABLE 9-17. Fish and wildlife sport and commercial needs, Puyallup Basin

	Unit	1965 Total	1980 Total	1980 Net[1]	2000 Total	2000 Net[1]	2020 Total	2020 Net[1]
Sport Fishing								
Salmon	1000 User-Days	124	206	82	379	255	643	519
Game Fish	1000 User-Days	607	1,014	407	1,595	988	2,551	1,944
Marine Fish	1000 User-Days	4	5	1	7	3	10	6
Shellfish	1000 User-Days	5	7	2	9	4	12	7
Total		740	1,232	492	1,990	1,250	3,216	2,476
Hunting	1000 User-Days	75	144	69	234	159	288	213
Commercial Fishing	1000 Pounds	--	--	108	--	1,928	--	4,278

[1] Cumulative need above 1965 activity.

Source: Appendix XI, Fish and Wildlife.

COMPREHENSIVE PLAN

BASIS OF PLANNING

Desires of Local People

During the initial public hearing in Olympia on October 23, 1964, there were several strong statements opposing the use of Tacoma's municipal water supply collection basins for recreational activities. Proposed hydroelectric power plant improvements for Tacoma City Light in other basins and the existence of several limited-scale, potential hydroelectric power sites in Pierce County were briefly discussed. A request was made for including in the Puget Sound and Adjacent Waters Study, an investigation of the feasibility of providing for needed deep draft navigation by dredging a canal between Seattle and Tacoma and by dredging in the Nisqually River delta. Land use, drainage and flood control problems in the Basin were also mentioned, and suggested watershed management measures were outlined. The need was expressed for using the study as a vehicle for planning the multiple-purpose use of the area's streams, including a long-range plan for enhancing the fish resource (see Appendix I, Digest of Public Hearings).

Summary of Basin Needs

The needs of the Puyallup Basin for 1980, 2000 and 2020 are summarized in Table 9-18.

General Planning

A wide range of alternative nonstorage and management opportunities were viewed in the Puyallup Basin. These included diversion structures, direct river pumping and treatment, desalinization, interbasin water transfer, further ground water utilization, and improved water yields through various watershed management practices to satisfy water supply needs of municipalities and industry, irrigated farming, water quality preservation and enhancement, and fish use. Levees, channelization, diversion, flood plain evacuation, bank protection, and improved land use management practices were considered as possible means of meeting flood control and watershed management needs. Opportunities considered for satisfaction of water quality needs were sewage collection and treatment facilities and minimum flows available to assimilate residual waste-loadings. The water and related land resource was examined in terms of projected land use pattern C_2, (see Projected Land Use) with the land needs of navigation, power, recreation, and fish and wildlife considered within this context.

There are storage sites on a number of rivers which could provide opportunities for hydroelectric power production, and water control. With storage greater utilization of the resource would allow satisfaction of water supply needs and minimum streamflow requirements for anadromous and resident fish. Storage could be developed at sites on the Puyallup and Carbon Rivers and on South Prairie and Voight Creeks. With storage there would be sufficient quantities of water to meet projected water supply needs even during a year of extreme low runoff

TABLE 9-18. Summary of needs, Puyallup Basin

Feature	Units	Cumulative Net Needs[1] 1980	2000	2020
M&I Water Supply	mgd	85.7	228.3	446.9
	(1000 Acre-Feet)	(96.0)	(257.2)	(501.5)
Irrigation	1000 Acre-Feet	5.9	17.7	23.7
Water Quality Control				
Waste (Requiring Treatment)	1000 Population Equivalents	1,063	2,013	3,019
Flow[2]	cfs	105	245	270
Navigation				
Commercial	1000 Short Tons	3,700	14,000	17,200
Pleasure Boats	Wet Moorages	3,000	7,100	15,050
Power[3]				
Flood Control	$1000 Damage Reduction	151	301	602
Watershed Management				
Flood Prevention	1000 Acres	48.1	48.1	48.1
Watershed Protection and Rehabilitation	1000 Acres	759.0	759.0	759.0
Water Management				
Agriculture	1000 Acres	12.0	19.9	26.6
Urban	1000 Acres	123.2	123.6	198.5
Recreation	1000 User-Days	3,100	7,800	16,100
Fish and Wildlife				
Sport				
Fishing	1000 User-Days	492	1,250	2,476
Hunting	1000 User-Days	69	159	213
Commercial Fishing	1000 Pounds-Fish	108	1,928	4,278

[1] See Water and Related Land Resource Needs for derivation of net needs.

[2] Puyallup River near Tacoma.

[3] Power needs have been projected for the Puget Sound Area only.

without reducing streamflows below historical minimums during critical periods for fish. For further information on minimum streamflows for fish see the Area discussion on Fish and Wildlife.

Alternative objectives were considered in developing the Comprehensive Plan. The objectives represented both ends of the spectrum of interests, i.e., economic efficiency and environmental quality as discussed in the Puget Sound Area section of this Appendix. The alternative elements considered in plan formulation are described under Alternative Elements.

The single-purpose Appendices, V through XIV, provided a wide array of solutions. Necessary adjustments were made to these solutions in the formulation of comprehensive plans for the Basin. These adjustments consisted of:

(a) A flood control storage site, shown in Appendix XII, on South Prairie Creek was not used. Flood plain management was considered to be the better solution for the long-range period with this stream left in a free-flowing state.

(b) Fish and wildlife measures contained in Appendix XI were modified with expansion and/or construction of additional artificial propagation facilities planned in lieu of several storage projects required for flood control and low flow augmentation.

SUMMARY OF PLAN

Early Action 1970-1980

During this period municipal and industrial water supply needs of the city of Tacoma would be satisfied by utilizing storage provided by the Howard A. Hanson project on the Green River. Tacoma would also utilize ground water sources to meet peak demands and during periods when turbidity makes the Green River water unuseable. Ground water resources would continue to supply the preponderance of small and rural communities and industry.

About 2,500 acres of cropland would be placed under irrigation with water supplied by individual farmers from both surface and ground sources.

Compliance with State water quality standards would be obtained through installation of adequate collection and treatment facilities. Industrial plants would provide adequate treatment prior to discharge and would install outfalls and diffusers to achieve maximum dilution and dispersion into Puget Sound. A water quality surveillance program would be expanded in order to provide an adequate monitoring system with sampling stations on marine and fresh water. A comprehensive sewerage plan would be developed for the Basin.

Navigation needs would be met through deepening of Hylebos, Port Industrial and Sitcum waterways to accommodate bulk cargo vessels and freighters. Lands found to be suitable for terminal or water transport-oriented industrial development would be retained for this purpose to insure future availability. Wet moorage would be provided for pleasure boaters through the construction of two small boat harbors with 1,550 moorage slips.

Power needs for the Basin would be satisfied by the Northwest Regional system. Future development for the satisfaction of Area power needs is discussed under Power in the Area portion of this Appendix.

During this period the community of Orting would be protected by a levee 6 miles in length. Flood plain management would provide an effective means of reducing future flood damages through land use zoning of lands in the flood plain consistent with the levels of flood protection. Floodproofing and warning systems also would be implemented. These measures would contribute significantly to the reduction of future flood damages.

Five small watershed multiple-purpose projects are planned for implementation during this period to achieve floodwater damage reduction, protection and rehabilitation, and water management. These are located in the following areas: Algona-Pacific, Clear Creek, Hylebos Creek, Wapato Creek, and Clover Creek. The structural measures in these projects consist of stabilized channels and outlet control structures. Important complements to the watershed structural projects are the programs of technical assistance and improved management with installation of land treatment and water management measures.

Campgrounds, picnic areas, beaches, and boat launching ramps would be developed on existing public lands together with the acquisition of additional land and water areas to satisfy recreational needs. Additional land and water areas would be acquired along the Puget Sound shoreline to provide needed marine parks. About 60 recreation sites are planned for expansion or development before 1980.

Land acquisition including access and fish and wildlife enhancement projects would be undertaken to increase the opportunities for this form of outdoor recreation. Additional fish hatcheries would be constructed for both resident and migratory fish together with rearing ponds, spawning channels and fish passage facilities at Electron Dam. Cross-sectional stream surveys would be undertaken during this period in order to determine the minimum and optimum streamflows required for fish production.

Long-Range, 1980-2020

Expansion of the existing water supply systems and development of new sources would take place commensurate with population and industrial growth to satisfy projected needs of municipalities, small and rural communities and industry.

An additional 7,500 acres of land would be placed under irrigation during this period with water supplied from surface and ground water by individual users.

Existing treatment and collection facilities would be expanded commensurate with the growth in population and industrial development to insure that the State water quality standards are continually complied with. The water quality surveillance program would be maintained.

Further terminal and water transport-oriented industrial development is envisioned during this period as facilities would be required to meet the navigation needs of the Basins. Hylebos and the Port Industrial waterway would be deepened to accommodate increased vessel drafts. The last site in the Basin suitable for a small boat harbor would be developed by the year 2000.

Power development may include pumped-storage at a number of the potential sites within the Basin. Oil or gas-fueled steam electric plants also may be located during this period to meet short-time peaking requirements. Development of nuclear electric generating plants may occur but definite scheduling of facilities and exact siting have not been completed and would be dependent upon future studies that considered shoreline characteristics nearness to major load centers and impacts on the environment.

During this period a storage project on the upper Puyallup River in connection with the levee at Orting, would provide 100-year protection in the flood plain from the dam site down to Sumner. A levee near South Prairie Creek would provide protection to agricultural lands near the community of South Prairie Creek. Flood plain management would be continued with zoning being required to guide future development and prevent unwarranted development in the flood plain.

Other watershed management needs in the Basin would be satisfied by the progressive development of four small watershed projects for floodwater damage prevention, rehabilitation and protection, and water management to make areas of the flood plains suitable for more efficient agricultural use. Upgrading of existing facilities and more intensive application of recurring and non-recurring land treatment practices would be required throughout the Basin. On-going watershed management programs which provide some degree of technical assistance and financial participation would be continued.

Additional development of campgrounds, picnic areas, and other recreation facilities would be undertaken after 1980 at about 90 sites throughout the Basin, on public lands as well as on private lands, with both public and private sectors participating in the providing of recreational facilities.

Additional fish and wildlife opportunities would be provided through anadromous and resident fish enhancement measures. A fish passage improvement is planned on Chambers Creek during the long-range period as well as additional spawning habitat development and construction of salmon hatcheries.

Table 9-19 summarizes the Puyallup Basin

TABLE 9-19. Comprehensive Plan, Puyallup Basin

		1970-1980				1980-2000	2000-2020	1970-2020
			Average Annual					
				Benefits				
Feature	Item	Investment[1] Costs ($1000)	Costs ($1000)	Gross ($1000)	Net ($1000)	Investment Costs ($1000)	Investment Costs ($1000)	Investment Costs ($1000)
Management Programs	Monitoring, Evaluation and							
Water Quality Control	Control Programs	2,600	--	--	--	4,200	5,100	11,900
Flood Control	Flood Plain Management	185	--	--	--	100	100	385
Watershed Management	Programs	135,672	--	--	--	94,123	138,264	368,059
Fish & Wildlife	Programs	403	--	--	--	630	630	7,663
Total Programs		$138,860				$ 99,053	$144,094	$382,007
Nonstorage Projects								
M&I Water Supply	Ground Water Use	13,154	1,239	1,239[5]	0	7,584	7,400	28,138
	Surface Water Use	28,909[4]	2,818	2,818[5]	0	28,932	52,207	110,048
Irrigation Water Supply	Ground Water Use	136	17	17[5]	0	231	109	476
	Surface Water Use	204	26	26[5]	0	449	231	884
Water Quality Control	Sewerage Treatment and Collection Facilities	34,000	1,964	1,964[5]	0	51,200	79,600	164,800
Navigation	Channels	5,430	318	389	71	4,488	0	9,918
	Small Boat Harbors[3]	(3,120)[3]	(200)[3]	(290)[3]	(90)[3]	(5,492)[3]	0	(8,612)[3]
Power[2]								
Flood Control	Channels and Levees	1,600	86	103	17	1,000[5]	0	2,600
Watershed Management	Flood Damage Prevention, Rehabilitation and Protection, and Water Management	4,972	271	382	111	4,167	0	9,139
Recreation	Land Acquisition, Access and Recreation Facilities	35,389	2,339	3,255	916	55,600	88,040	179,029
Fish & Wildlife	Land Acquisition, Access and Enhancement Facilities	3,306	366	849	483	8,039	11,864	23,209
Total Nonstorage		$127,100	$ 9,444	$11,042	$1,598	$161,090	$239,451	$528,241
Storage Projects								
	Puyallup (Puyallup River)							
Flood Control		0	0	0	0	26,500	0	26,500
	Total Storage	$ 0	$ 0	$ 0	$ 0	$ 26,500	$ 0	$ 26,500
Total Program and Projects		$265,960	$16,567	$24,695	$8,128	$287,243	$383,545	$936,748

1 Includes cumulative annual program costs for the period for management features and capital costs for nonstorage and storage projects.

2 Power facilities not included in Basin plan.

3 General Navigation facilities cost and benefits for public small boat harbors only. Total pleasure boat facilities costs and benefits included with Recreation.

4 Includes costs for modifying Howard A. Hanson project.

5 Average annual benefits assumed equal to average annual costs.

elements of the Comprehensive Plan, showing the benefits and costs for the early action portion of the Plan, and provides a summary of investment costs by water resource functions for the entire 50-year period ending in 2020. The early action portion of the Plan includes programs amounting to $138,860,000 and projects costing $127,100,000 for a total investment of $265,960,000 Program and project investment costs for the 1980-2000 period amount to $287,243,000 and for the 2000-2020 period, $383,545,000; for a total 50-year investment of $936,748,000.

FEATURES OF THE COMPREHENSIVE PLAN

Municipal and Industrial Water Supply

The city of Tacoma is expected to remain the largest supplier of both municipal and industrial water in the Puyallup Basin. The future water supply needs of Tacoma are expected to be supplied from both ground and surface water sources. By the year 2020 Tacoma is planned as the major purveyor, delivering 73 percent of the projected water used in the Basin. Fort Lewis, Puyallup and Steilacoom are expected to continue using ground water sources. Buckley, Sumner, Orting and other rural communities would continue to obtain their waters from both surface and ground water sources. The preponderance of future self-supplied industrial water would be obtained from ground sources. The portion of the Comprehensive Plan dealing with municipal and industrial water supply follows:

1970-1980—The city of Tacoma would expand its use of the Green River surface water source during this period to meet the 1980 level of need of 128 mgd. Further utilization of Green River water is dependent on modification of Howard A. Hanson project to allow conservation storage. Allocation of water for municipal use as well as possible flow augmentation for fishery enhancement requires additional studies. Ground water sources would augment the surface water and would be utilized during times of peak demand or unacceptable turbidity from the surface source.

Water supply needs of Fort Lewis and Steilacoom are planned for satisfaction by continued utilization of ground water sources. Buckley, Sumner, Orting, Bonney Lake, Wilkeson and other rural communities would meet their needs by further utilization of both surface and ground water sources. Puyallup would meet future needs by diversion from Tacoma's transmission line. Self-supplied industry in the Basin would require additional water by 1980 with the great majority of this water to be supplied from ground sources. The primary users of self-supplied industrial water are the paper and allied industries. The projected average daily water use for the Puyallup Basin planned supply and transmission investments and average annual costs would be:

Development	Needed by Year	1980 Average Daily Water Use (mgd)	Supply and Transmission Investment ($1000)	Average Annual Costs Interest & Amort.[1] ($1000)	O&M[2] ($1000)	Total ($1000)	Benefits[4] ($1000)
Tacoma		128					
Development of additional diversion facilities from Green River (Howard Hanson Dam)	1975		26,800[3]	1,347	2,398	2,745	2,745
Puyallup		6					
Surface water diversion from Tacoma	1978		2,009	94	62	156	156
Fort Lewis		14					
Additional ground water development	1975		594	28	149	177	177
Small and Rural Community Systems		18					
Surface water development	1975		12,000	561	198	759	759
Self-Supplied Industry		18					
Additional ground water development	1980		660	31	189	220	220
Total		184	$42,063	$2,061	$1,996	$4,057	$4,057

1 Interest and amortization of capital investment costs.

2 Total incremental increase in annual operation and maintenance cost including pumping and treatment costs.

3 Includes allocated cost of multiple-purpose storage project.

4 Average annual benefits assumed equal to average annual costs.

1980-2000—Water needs of the city of Tacoma in this period would be met by increased releases from the Howard A. Hanson project on the Green River. Tacoma also would continue to develop ground water sources to meet peak demands or when the turbidity in the Green River reaches an intolerable level. Puyallup would continue to obtain its water from Tacoma's Green River transmission line. The increased need for water at Fort Lewis would continue to be met by utilization of ground sources. The small and rural communities within the Basin would develop local ground water sources or obtain water from the city of Tacoma. Self-supplied industrial increased needs in this time period would be met by further development of ground water sources. A summary of projected average daily use and investment costs is provided for municipal and industrial water supply required by the year 2000 in the following tabulation:

Development	Needed by Year	2000 Average Daily Water Use (mgd)	Supply and Transmission Investment ($1000)
Tacoma		235	
Additional development of Green River surface and ground water	1990		24,150
Puyallup		13	
Surface water diversion from Tacoma	1998		5,100
Fort Lewis		21	
Additional ground water development	1995		984
Small and Rural Communities		29	
Surface water diversion for Tacoma	1995		5,382
Self-Supplied Industry		30	
Additional ground water development	1995		900
Total		328	$36,516

2000-2020—Water demand of the city of Tacoma in this period would be satisfied by developing a surface source on the Puyallup River near Electron. Other water users would continue to use sources previously developed. The summary projected average daily use and investment costs are provided for municipal and industrial water supply required by the year 2020 in the following tabulation:

Development	Needed by Year	2020 Average Daily Water Use (mgd)	Supply and Transmission Investment ($1000)
Tacoma		400	
Surface water from Puyallup River and ground water	2005		42,200
Puyallup		21	
Surface water diversion from Tacoma	2015		4,162
Fort Lewis		29	
Additional ground water development	2010		990
Small and Rural Communities		49	
Additional surface water diversion from Tacoma	2010		10,045
Self-Supplied Industry		46	
Additional surface and ground water development	2015		2,210
Total		545	$55,607

Irrigation

Approximately 3,700 acres of land are currently irrigated. Lands placed under irrigation are projected to increase to 6,200 acres by 1980, reach 11,200 acres by the year 2000, and 13,700 acres by the year 2020. Of the 10,000 acres of additional land expected to be irrigated by the year 2020, 6,500 acres would be supplied from surface water sources and the remaining 3,500 acres from ground water sources. The following irrigation development are provided for in the Comprehensive Plan:

1970-1980—Increased ground water uses planned and surface diversion of water pumped directly from adjacent rivers would be:

1970-1980 New Irrigation Area		Diversion		Net Depletions	
Ground Water Supply (acres)	Surface Water Supply (acres)	Ground Water (acre-feet)	Surface Water (acre-feet)	Ground Water (acre-feet)	Surface Water (acre-feet)
1,000	1,500	1,900	4,000	1,600	2,300

Private investment costs for the new surface and ground water diversions is estimated at $135 per acre for a total investment cost of $340,000. Total annual charges would be $43,500 including operation and maintenance costs of $27,500. The investment costs allow for on-farm sprinkler systems and pumping equipment.

1980-2000—Increased ground water use and surface diversion are planned during this period as shown below:

1980-2000 New Irrigation Area		Diversion		Net Depletions	
Ground Water Supply (acres)	Surface Water Supply (acres)	Ground Water (acre-feet)	Surface Water (acre-feet)	Ground Water (acre-feet)	Surface Water (acre-feet)
1,700	3,300	3,800	8,000	2,600	5,100

Private investment cost for the new surface and ground water diversions is estimated at $135 per acre for a total investment cost of $680,000.

2000-2020—Further ground water use and surface diversion is planned. Water pumped from wells or directly from adjacent rivers is tabulated below:

2000-2020 New Irrigation Area		Diversion		Net Depletions	
Ground Water Supply (acres)	Surface Water Supply (acres)	Ground Water (acre-feet)	Surface Water (acre-feet)	Ground Water (acre-feet)	Surface Water (acre-feet)
800	1,700	2,000	4,000	1,200	2,600

Private investment cost for the new surface and ground water diversion is estimated at $135 per acre for a total investment cost of $340,000.

Water Quality Control

Present and future wasteloadings of the Basin require a large investment for adequate collection and treatment facilities. Flows in the Puyallup River are expected to adequately assimilate projected residual wasteloadings in compliance with State water quality standards. Water quality control elements of the Comprehensive Plan would be:

1970-1980—The installation of sewerage systems with secondary treatment and disinfection facilities is planned for the cities of Carbonado, Orting, Wilkeson, Bonney Lake, Algona and Pacific. The cities of Buckley, Sumner and Puyallup would provide secondary treatment and disinfection facilities for their collected wastes. Tacoma would provide secondary treatment, disinfection and adequate outfall facilities. The food processing plants located along the Puyallup River and its tributaries would provide secondary treatment or connect to municipal systems.

On Commencement Bay, the pulp and paper industry would provide secondary treatment of their wastes and an adequate outfall into the bay. Other industries located on Commencement Bay which produce toxic waste, would provide adequate treatment prior to discharging their effluent into the bay. An industry which discharges its wastes into the Chambers Creek estuary would provide secondary treatment and an adequate outfall into deep water. Fort Lewis would provide secondary treatment, disinfection and an adequate outfall. The Plan would meet the requirements of water quality standards as set forth in Implementation and Enforcement Plan for Interstate Waters, 1967 and Intrastate Waters, 1969 for the State of Washington applies to the Puyallup Basin. The investment costs of the waste treatment collection facilities are estimated below. Program costs for water quality surveillance also are included.

Water Quality Control
1970-1980

Feature	Investment Costs ($1000)	Average Annual Costs: Interest & Amortization ($1000)	Average Annual Costs: Operation & Maintenance ($1000)	Average Annual Costs: Total ($1000)	Average Annual Benefits[2] ($1000)
Monitoring, Evaluation and Control Program	2,600[1]				
Industrial Wastes					
Treatment	5,600	262	62	324	324
Municipal Wastes					
Treatment	10,800	505	117	622	622
Sewers	15,800	739	175	914	914
Subtotal	$26,600	$1,244	$292	$1,536	$1,536
Recreation Waste					
Treatment	1,800	84	20	104	104
Total	$36,600	$1,590	$374	$1,964	$1,964

1 Cumulative annual program costs for the period.

2 Average annual benefits assumed at least equal to average annual costs.

1980-2020—Expansion of industry, new developments, and growth of urban and recreation areas require that new sewer interception systems be installed and treatment facilities be enlarged and/or constructed. Summarized in the following tabulation are estimated investment costs for water quality control for the periods 1980-2000 and 2000-2020.

Water Quality Control
1980-2020

Feature	Investment Costs ($1000) 1980-2000	2000-2020
Monitoring, Evaluation and Control Program	4,200[1]	5,100[1]
Industrial Wastes		
Treatment	7,200	18,400
Municipal Wastes		
Treatment	16,700	23,600
Sewers	24,900	35,200
Subtotal	$46,600	$58,800
Recreation Wastes		
Treatment	2,400	2,400
Total	$55,100	$84,400

[1] Cumulative annual program costs for the period.

Navigation

Navigation is expected to continue to be an mportant contribution to the economy of the 'uyallup Basin. The Port of Tacoma is engaged in a iodernization program and development of new idustrial and terminal lands to meet expected icreases and commodity movements. Planned mprovements are discussed by the following time periods:

1970-1980—Additional lands would be developed for water transport-oriented industries and deep draft terminals. These lands, shown in Appendix VII, Navigation, are located in the Puyallup delta, along Commencement Bay and in Tacoma. Improvement of the navigation channels at Hylebos Waterway, Port Industrial Waterway and Sitcum Waterway are planned before 1980 to meet the increasing vessel drafts. These improvements are tabulated below:

Navigation Improvements
1970-1980

Channel	Length (miles)	Depth (feet)	Investment Costs ($1000)	Average Annual Costs: Interest & Amortization ($1000)	Average Annual Costs: Operation & Maintenance ($1000)	Average Annual Costs: Total ($1000)	Average Annual: Benefits ($1000)
Hylebos Waterway	2.8	46	1,742	81	27	108	119
Port Industrial Waterway	1.9	52	2,123	99	24	123	152
Sitcum Waterway	0.7	78	1,565	73	14	87	118
Total	5.4		$5,430	$253	$65	$318	$389

During this period development of two small boat harbors is planned. Approximately 1,550 wet moorages are included for construction by public agencies, as compared to the need of 4,350 moorages. The difference is assumed, for purposes of this study, to be met by further private investment in marina facilities. The construction costs and average annual costs and benefits of the following small boat harbor projects tentatively scheduled for construction by 1980:

Small Boat Harbor Projects
1970-1980

Location	Wet Moorages	Investment Costs ($1000)	Average Costs ($1000)	Annual[1] Benefits ($1000)
Hylebos Waterway	890	1,800	114	166
Titlow-Day Island	660	1,320	86	124
Total	1,550	$3,120	$200	$290

[1] General navigation facilities costs and benefits only, based on 50-year economic life at a 4-5/8% interest rate. Total pleasure boat facilities costs and benefits included with Recreation.

1980-2000—During this period additional development is required of lands for water transport-oriented industries and deep draft terminals. Further deepening of the Hylebos and Port Industrial Waterways would be undertaken as tabulated below:

Navigation Improvements
1980-2000

Location	Channel Depth (feet)	Channel Length (miles)	Investment Costs ($1000)
Hylebos Waterway	78	1.4	2,406
Port Industrial Waterway	106	0.7	2,082

During this period the last site found to be favorable for a small boat harbor would be developed. Unmet needs are planned for satisfaction in the adjacent Nisqually-Deschutes Basins. The public small boat harbor project scheduled for this period is tabulated below:

Small Boat Harbor Project
1980-2000

Location	Wet Moorages	Investment Cost ($1000)
Dumas Bay	2,720	5,492

2000-2020—No further development of navigation facilities or small boat harbors are planned after the year 2000.

Power

The electrical energy needs of the Basin are satisfied on a regional basis. Only a minor amount of electric power is generated at two power plants located on the Puyallup and White Rivers. Appendix IX, Power, forecasts availability of adequate power from existing sources to satisfy needs to about 1980. Increased power generation would be necessary to meet the 2000 and 2020 needs. Base-load nuclear electric generating plants are anticipated at a number of sites in the Puget Sound Area. A proposed development of any plan would require that adverse impacts on the environment be considered and the means to lessen these impacts on specific project studies undertaken. Although nuclear power plants have not been identified for the Puyallup Basin there are three pumped-storage sites in the upper Basin which have a potential for peaking power production. For additional discussion of power, see the Puget Sound Area.

Flood Control

Flood protection objectives for the Basin would be met by the structural elements proposed in this Plan. These objectives have been defined in terms of flood frequency with industrial and urban lands recommended for 100-year level of flood protection, agricultural lands requiring at least 25-year level of protection, and lands in the flood plain to be used for parks, golf courses and general recreation requiring a level of flood protection of 10-15 years. The portion of the Plan dealing with flood control is discussed as follows:

1970-1980—A levee project in the vicinity of Orting on both the Puyallup and Carbon Rivers would be constructed during this period. The project would protect the community of Orting and rural areas in the immediate vicinity. Flood plain management including flood plain zoning and regulation also would be implemented. The tabulation below summarizes the early action flood control programs and projects for the Puyallup Basin.

1980-2000—A storage project would be constructed before the year 2000 on the upper Puyallup River to provide the flood plain from the dam site to Sumner with 100-year level of protection. This project would have 24,000 acre-feet of effective flood control storage and is estimated to cost $26,500,000. During detailed planning studies other purposes including power, recreation, irrigation and municipal and industrial water supply would be investigated.

An additional levee system 2 miles in length to protect 1,000 acres of agricultural land against floods of up to 25-year frequency is proposed for the left bank of South Prairie Creek in the vicinity of South Prairie at an estimated cost of $1,000,000. Flood plain management would be continued during this period at an estimated cost of $100,000.

2000-2020—No further structural measures are planned with flood plain management continued at an estimated cost of $100,000.

Flood Control Element	Design Capacity (cfs)	Investment Costs ($1000)	Average Annual[1] Costs: Interest & Amortization ($1000)	Average Annual[1] Costs: Operation & Maintenance ($1000)	Average Annual[1] Costs: Total ($1000)	Average Annual[1] Benefits ($1000)
Channel and Levee Construction						
Levees in the vicinity of Orting	22,000	1,600	75	11	86	103
Flood Plain Management		185[2]				105
Total		$1,785				$208

[1] Allocated flood control costs and benefits shown for storage projects.

[2] Cumulative program costs for the period.

Watershed Management

The needs for watershed management in the Puyallup Basin include floodwater damage reduction, rehabilitation and protection of watershed areas and water management for a variety of purposes on rural and urban lands. The objectives of watershed management are to enable development of the resource of the Basin to achieve the highest level of sustained production of food and fiber that is economically justified, and to provide for development of needed urban areas in locations not subject to floodwater or other hazards. The watershed management projects included in the Comprehensive Plan are viewed as complementary to the existing and proposed major flood control projects also contained within the Plan. Continuing investment is required, both public and private, to insure protection of water and related land. This investment would be in the form of financial assistance, technical assistance, research, education and information. New installations, upgrading of existing facilities and improvements or more intensive application of land management practices would be required for flood protection, water management, and watershed rehabilitation and protection. While the acreage requiring treatment remains fairly constant the intensity of treatment application by time period and the composition of the combined measures varies with inherent capability of land as well as with the kind and intensity of use.

Federal and State land administrative agencies are responsible for the installation of these measures on land assigned to their management, while initiative of the individual property owner is required for installation of practices on lands in private ownership. Various Federal agencies in the State have programs of technical and financial assistance for individuals, local organizations and sub-divisions of government including the Pierce County Soil and Water Conservation District. The schedule of watershed management projects and programs provided for in the Comprehensive Plan would be:

1970-1980–Projects planned for early action are described briefly as follows:

The Algona-Pacific Watershed outlets into the White River upstream from Sumner and occupies the relatively level flood plain and a portion of the glacial moraine on the west side of the White River. The valley is utilized for agricultural and urban purposes and the hill land is heavily forested, mostly in mixed stands of Douglas fir and red alder. This area is rapidly being urbanized and none of it is expected to remain in commercial forest. The steep slopes of the hills are critical erosion areas and should remain in forest or great care should be taken in the developments which are placed in these areas. The watershed contains 6,457 acres of land, of which 1,502 acres are cropland, 1,435 acres are forest, and 3,520 acres are rural nonfarm and urban.

The project is designed for flood prevention in agricultural and urban areas and water management on agricultural lands.

The structural works of improvement would consist of 12 miles of improved and stabilized channel. Installation cost of the structural measures is estimated to be $594,000 of which the Federal share is $444,000, and the local share is $150,000. Average annual cost of the project including $5,100 for operation and maintenance is $32,900. Benefits from damage reduction and drainage would provide a benefit-cost ratio of 1.6 to 1. To achieve benefits made possible by the structural works it would be possible for local interests to install necessary land treatment measures for erosion control and flood prevention, costing approximately $108,810, water management measures estimated to cost $225,466, and forest protection and management practices costing $32,546, for a total of $366,822. The total cost of installing the structural measures and the land treatment measures is $960,822.

Clear Creek Watershed is located adjacent to the city of Tacoma on the east side. The watershed is drained by four streams which originate on the terrace upland and flow northward into the flood plain of the Puyallup River. These streams join together in Clear Creek and outlet into the Puyallup River. Flood and drainage problems on the upland terrace area are caused by inadequate channels and floods on the flood plain are due to both inadequate channels and poor outlets.

The forest land is restricted to the upland portion of the watershed. The most critical erosion area is where the uplands rise sharply from the bottom land and protective measures are needed on the slope to insure stability of the soil. The area included in this watershed contains 8,060 acres, of which 790 acres are cropland, 990 acres are forest, 6,165 acres are rural nonfarm and urban, and 115 acres are in miscellaneous uses.

The project is designed for flood prevention in

agricultural and urban areas, and drainage of agricultural lands. The structural works of improvement would consist of 21 miles of improved and stabilized channel and one outlet structure consisting of floodgates and a pump. Installation cost of the structural measures is estimated to be $1,901,000, of which the Federal share is $1,102,000 and the local share is $799,000. Average annual cost of the project including $15,700 for operation and maintenance is $104,600. Benefits from damage reduction and drainage would provide a benefit-cost ratio of 1.3 to 1. To achieve benefits made possible by the structural measures local interests would install necessary land treatment measures for erosion control and flood prevention costing approximately $57,240, water management measures expected to cost $1,197,187 and forest protection and management practices costing $22,453 for a total of $1,276,880. The total cost of installing the structural measures and the land treatment measures is $3,177,880.

Hylebos Creek Watershed is located between Seattle and Tacoma and outlets into Commencement Bay at Tacoma. The lower part of the watershed, the portion on the Puyallup River flood plain, is agricultural and urban; however, this would probably become industrial in the not too distant future. Flood and drainage problems are caused by inadequate channels and lack of maintenance of existing channels.

All of the upland areas of this watershed were well forested with young growth Douglas fir up until thirty years ago. Since then, there has been a gradual acceleration of urbanization until only a few blocks of forested land remains, and even these are dotted with suburban residences. Some effort should be made to reserve part of these remaining tracts for parks. Development around the many small lakes should be planned to preserve the attractiveness of the landscape and prevent pollution of the water resources. The steep slope from the upland plateau to the valley is the most critical erosion area and developments here should be established with care.

The project is designed for flood prevention in agricultural and urban areas, and water management on agricultural lands. The area included contains 16,000 areas, of which 1,281 acres are cropland, 7,239 acres are forest, 7,303 acres are rural nonfarm and urban, and 177 acres are in miscellaneous uses.

The works of improvement would consist of 7 miles of improved and stabilized channel and one outlet structure consisting of floodgates and a pump. The installation cost of structural measures is estimated to be $642,000, of which the Federal share is $386,000, and the local share is $256,000. Average annual cost of the project including $4,300 for operation and maintenance is $34,300. Benefits from damage reduction and drainage would provide a benefit-cost ratio of 1.5 to 1. To achieve benefits made possible by the structural measures local interests would install necessary land treatment measures for erosion control and flood management costing approximately $92,812, water management measures expected to cost $281,375, and forest production and management practices costing $164,180 for a total of $538,367. The total cost of installing the structural measures and the land treatment measures is $1,180,367.

Wapato Creek Watershed is entirely on the north side of the flood plain of the Puyallup River and outlets into Commencement Bay. The lower end of the watershed is an industrial area and this area is expanding up the valley. Most of the watershed is a high-producing agricultural region; however, it is adjacent to both Tacoma and Puyallup and urbanization is proceeding rapidly. Only 13 percent of the land remains in forest and this forest land is restricted to the upland portion. The most critical erosion area is where the uplands rise sharply from the bottom land. Protective measures are needed on this slope to insure stability of the soil. The area contains 6,407 acres of land of which 1,699 acres are cropland, 829 acres are forest, 3,859 acres are rural nonfarm and urban, and 20 acres are in miscellaneous uses.

The project as designed is for flood prevention in agricultural and urban areas and water management on agricultural lands. The structural works of improvement would consist of 7 miles of improved and stabilized channel and one outlet structure consisting of floodgates and a pump. The installation cost of structural measures is estimated to be $979,000, of which the Federal share is $604,000, and the local share is $375,000. Average annual cost of the project including $8,100 for operation and maintenance is $53,900. Benefits from damage reduction and drainage would provide a benefit-cost ratio of 1.3 to 1. To achieve benefits made possible by the structural measures local interests would install necessary land treatment measures for erosion control and flood management costing approximately $123,098, water management measures expected to cost $365,867, and forest protection and management practices costing $18,802, for a total $507,767. The

total cost of installing the structural measures and the land treatment measures is $1,486,767.

Clover Creek Watershed is located on the south and west sides of Tacoma and the creek flows through McChord Air Force Base. Clover Creek is tributary to Steilacoom Lake, which in turn outlets through Chambers Creek and Chambers Bay into Puget Sound.

Much of the area within this watershed is urban and industrial. Some forest remains but urbanization is gradually eliminating the forest.

Clover Creek has inadequate or blocked channels and a flat gradient. Agricultural areas in the upper watershed are handicapped by floodwater and poor drainage conditions. The area contains 88,092 acres, of which 1,978 acres are cropland, 22,907 acres are forest, 60,241 acres are rural nonfarm and urban, and 2,966 acres are in miscellaneous uses.

The project is designed for flood prevention in agricultural and urban areas and drainage of agricultural lands. The structural works of improvement would consist of 14 miles of improved and stabilized channels. The installation cost is estimated to be $856,000, of which the Federal share is $489,000, and the local share is $367,000. Average annual cost of the project including $5,400 for operation and maintenance is $45,400. Benefits from damage reduction and drainage would provide a benefit-cost ratio of 1.6 to 1. To achieve benefits made possible by the structural measures local interests would install necessary land treatment measures for erosion control and flood management costing approximately $143,302, water management measures expected to cost $166,868, and forest protection and management practices costing $519,531, for a total of $829,701. The total cost of installing the structural measures and the land treatment measures is $1,685,701.

Programs tabulated below include the complementary features to the projects discussed above and other onfarm and urban on-site practices required in the Basin.

Watershed Management Practices
1970-1980

Program	Area (acres)	Cost ($1000)
Technical assistance and management	635,875	18,436
Federal, regular		10,094
Federal, accelerated		445
Subtotal		$ 10,529
Installation of practices (non-Federal)		
State and corporate		7,897
Land treatment	325,701	3,745
Water management		
Agricultural	11,952	2,790
Urban	82,001	110,701
Subtotal		$125,133
Total		$135,672

1980-2000—The projects and programs scheduled for this period are tabulated below with estimated costs.

Watershed Management Practices
1980-2000

Program	Area (acres)	Cost ($1000)
Technical assistance		
and management	635,483	
Federal, regular		19,171
Federal, accelerated		593
Subtotal		$19,764
Installation of practices		
(non-Federal)		
State and corporate		10,529
Land treatment	325,309	4,957
Water management		
Agricultural	14,607	2,759
Urban	41,566	56,114
Subtotal		$74,359
Total		$94,123

Project[1]		Structural Measures Installation ($1000)
White River	307,682	1,667
Carbon River	87,590	200
Puyallup River	160,763	1,500
South Prairie Creek	55,976	800
Total	612,011	$ 4,167

2000-2020—The programs recommended for implementation during this period are shown in the following tabulation. No projects are programmed for this period.

Watershed Management Practices
2000-2020

Program	Area (acres)	Cost ($1000)
Technical assistance		
and management	560,567	
Federal, regular		19,564
Federal, accelerated		0
Subtotal		$ 19,564
Installation of practices		
(non-Federal)		
State and corporate		10,529
Land treatment	250,393	4,034
Water management		
Agricultural	15,000	3,000
Urban	74,916	101,137
Subtotal		$118,600
Total		$138,264

Recreation

With the growing and increasingly mobile population in the metropolitan centers of Puget Sound Area, the provision of sufficient facilities to satisfy outdoor recreation needs is a serious problem. Although natural resources in the Puyallup Basin are abundant, inadequate facilities and other constraints currently prevent proper utilization of the resource for recreation. A need exists for the preservation and public accessibility of the many natural attractions in the Puyallup Basin, including the shoreline of Puget Sound, Lake Tapps, American Lake, and portions of the Puyallup River and its tributaries. The many miles of shoreline of the Puyallup River and its tributaries should be available to the public. Comprehensive land use planning is required in order to guide urban development so that the environmental quality needs of the Basin's population are met.

The broad recreation goal is to promote well-planned development and protection of existing resources, and to provide opportunities for the satisfaction of present and future outdoor recreation demand. Based on Federal ownership of land, plans and programs of recreation suppliers, expected population concentrations, as well as outdoor recreation needs, the assumption is made that Federal agencies would provide 20 percent of the required water-related opportunities, while the State, county and local agencies and private interests can supply 20, 35 and 25 percent, respectively.

Additional facilities and acquisition and development of land and water areas are required in order to satisfy the water related outdoor recreation needs. The specific land and water area requirements are shown in the following tabulation:

The recreation development, as provided for below is intended to be compatible with Washington's State-Wide Outdoor Recreation and Open Space Plan.

1970-1980—Satisfaction of urgently needed marine-oriented recreation needs is called for by construction of small boat harbors on the shoreline as discussed under Navigation, with private investments in marina facilities also viewed as necessary to supply wet and dry moorages for pleasure boaters. Improvement and further development of recreation facilities at the 118 publicly-administered outdoor recreation areas within the Basin, along with development of new areas on existing publicly-administered land is planned during this period. Access and improvement to State shorelines along the Puyallup and White Rivers and numerous points on Puget Sound is called for, together with the designation of a network of scenic roads to provide travel links between recreation attractions, which would enhance driving for pleasure and sightseeing opportunities within the Basin. Where practical, hiking and riding trails should also be developed within the corridor of scenic roads.

Over 60 recreation areas are planned for expansion or development during this period. Investigation would be undertaken for obtaining a safe public use easement over and adjacent to railroad tracks, paralleling the shorelines of the Puget Sound. Scenic access easements would be acquired along the rivers and streams throughout the Basin, to insure that greenbelts are provided within areas which are presently urbanized, and those destined for residential development. Preservation of portions of the natural flood plain along the Puyallup River as open space would be consistent with a portion of the Comprehensive Plan discussed under Flood Control.

Recreation Land and Water Requirements
1960-2020

Activity	Unit	1960 Land	1960 Water	1980 Land	1980 Water	2000 Land	2000 Water	2020 Land	2020 Water
Swimming									
Beach	Acres	0	0	0	0	20	3	60	11
Pools	Sq. Ft.	44,200	21,600	177,200	88,600	431,200	215,600	888,200	443,600
Boating, Sailing, and Water Skiing	Acres	16	0	91	29,560	231	95,560	491	222,560
Camping	Acres	236	0	666	0	1,666	0	3,266	0
Picnicking	Acres	122	0	307	0	607	0	1,007	0
Hiking	Miles	0	0	17	0	187	0	547	0

Source: Appendix X, Recreation.

A State system is suggested to retain important recreation rivers or river segments in their natural free-flowing state with the Carbon, and portions of the White and Puyallup Rivers recommended for study to determine if these streams or portions thereof may qualify for protection.

Investments for recreation facilities are tabulated below for the various water-related improvements.

Outdoor Recreation Improvements
1970-1980

Feature	Investment Costs ($1000)	Average Annual Costs: Interest & Amortization ($1000)	Average Annual Costs: Operation & Maintenance ($1000)	Average Annual Costs: Total ($1000)	Average Annual Benefits ($1000)
Campgrounds	9,324				
Picnic areas	1,288				
Trails	102				
Swimming pools	2,215				
Boating facilities	6,714				
Planning and design	4,911				
Land acquisition	10,835				
Total	$35,389	$1,655	$684	$2,339	$3,255

1980-2000–Before the year 2000, more extensive development of public lands is anticipated, although acquisition of private lands also would be required. All types of recreational development, including small boat basins would continue during this period. Total recreation development costs for this period are estimated at $36,700,000 with land acquisition estimated at $18,900,000, including buffer zones. Over 40 recreation sites are planned for expansion or new development.

2000-2020–Prior to the year 2020, more extensive development of public lands is anticipated, with further acquisition of private lands. Total recreation development costs for this period are estimated at $55,100,000 with land acquisition estimated at $32,940,000 including buffer zones. Nearly 50 recreation areas are planned for expansion or new development.

Fish and Wildlife

The Puyallup Basin offers numerous opportunities for projects and programs that, if implemented, would maintain and possibly enhance wildlife populations, and increase fish and shellfish production. Portions of the Comprehensive Plan dealing with fish and wildlife are:

1970-1980—Important measures to fulfill fish needs planned for early action include a fish ladder and screens at the Electron Diversion on the Puyallup River and alteration of upstream and downstream migrant fish-passage facilities associated with the White River diversion dam. Expansion of existing artificial propagation facilities are proposed at this time in lieu of low flow augmentation in the White River. Augmentation of flows, either through storage or reduction in diversion by Puget Sound Power and Light, should be studied further to determine the best means for satisfying this critical need.

Additional projects to enhance fish include acquisition and development of access to eight lakes, expansion of the Puyallup trout hatchery, acquisition and development of steelhead rearing facilities, acquisition and development of 40 miles of streambank access, construction of a new game fish hatchery, channel clearance, debris removal, and acquisition and development of five saltwater access areas.

Important projects to propagate game population include acquisition of 600 acres of upland-bird habitat in the White River valley, enlarge game farms to produce 3,000 additional pheasants, and big game habitat improvement.

Before 1980, programs would be implemented which benefit both hunters and fishermen. These programs include the development of new fish toxicants, streams and lake surveys, fish disease control and lake fertilization techniques which would not adversely affect water quality. Those programs associated with game animals include cooperative programs with private land owners to preserve habitat and insure hunter success, development of educational programs to stress renewable aspects and proper harvest of wildlife, and new methods for wildlife population analysis, habitat improvement techniques, and compatible forest-wildlife practices. Projects and programs for fish and wildlife preservation and enhancement are tabulated below:

Fish and Wildlife Projects and Programs
1970-1980

Projects

a. Acquisition and development of eight lake access areas.
b. Construction of trout hatchery.
c. Expansion of fish hatchery for trout.
d. Fish passage facilities at Electron Dam.
e. Acquisition and development of 40 miles of stream access.
f. Fish passage improvements at White River diversion dam and increased salmon production on White River through artificial propagation facilities.
g. Construction of steelhead rearing facilities.
h. Acquisition and development of five saltwater access areas.
i. Acquisition and development of 600 acres of upland-bird habitat.
j. Expansion of game farm to produce an additional 3,000 pheasants.

Programs

k. Mark all State-owned second class tideland.
l. Stream and lake surveys.
m. Develop new methods of lake and stream rehabilitation including fish toxicants.
n. Develop lake and stream fertilization techniques.
o. Cross-sectional survey to determine optimum and minimum fish flows.
p. Development of cooperative programs with land owners to preserve wildlife habitat and assure access.
q. Development of educational programs regarding value of wildlife and spiny-ray fish.
r. Development of compatible forest-wildlife management techniques.
s. Conduct range surveys of big game.

Fish and Wildlife
Project and Program Costs
1970-1980

Feature	Investment Costs ($1000)	Average Annual Costs: Interest & Amortization ($1000)	Average Annual Costs: Operation & Maintenance ($1000)	Average Annual Costs: Total ($1000)	Average Annual Benefits ($1000)
Projects	3,306	155	211	366	849
Programs	403[1]				647[2]
Total	$3,709				$1,496

[1] Cumulative program costs for the period.

[2] Some of program benefits included in with project benefits.

1980-2000—Projects planned for implementation prior to the year 2000 include fish passage on Chambers Creek which would make an additional 8 miles of stream available for spawning and rearing of fish. Improvement projects would be undertaken on eight streams to provide an additional 53 miles of fish habitat. One salmon hatchery would be constructed during the period, as would a spawning channel 1 mile in length. This hatchery would be of sufficient size to provide benefits equivalent to those possible from flood control and flow augmentation measures recommended in Appendix XI, Fish and Wildlife. Programs initiated before 1980 would be continued in this period.

Project and program costs are summarized below:

Fish and Wildlife
Projects and Programs
1980-2000

Feature	Investment Costs ($1000)
Projects	8,039
Programs	630[1]
Total	$8,669

[1] Cumulative program costs for the period.

2000-2020—Four salmon hatcheries or other equivalent artificial fish production facilities would be constructed and a spawning channel 1 mile in length. Sixteen acres of rearing facilities would be provided for migratory salmon. Programs initiated prior to the year 2000 to provide fishing and hunting opportunities would be continued.

Project and program costs are summarized in the following:

Fish and Wildlife
Projects and Programs
2000-2020

Feature	Investment Costs ($1000)
Projects	11,864
Programs	630[1]
Total	$12,494

[1] Cumulative program costs for the period.

COST-BENEFIT SUMMARY

The investment costs by plan feature are shown in Tables 9-20 and 9-21 for the Puyallup Basin with the costs distributed between Federal, State, local and private interests. Average annual costs and benefits also are shown for projects recommended for implementation prior to 1980. The investment costs include cumulative annual program costs for each of the three planning periods as shown in Table 9-20 and capital project costs as shown in Table 9-21. Interest and amortization costs are based on a 100-year economic life with appropriate allowances made for major replacements. An interest rate of 4-5/8 percent was used in the economic analysis. All measures proposed for early action are justified on the basis of tangible benefits. Benefits for municipal and industrial water supply and water quality improvement were assumed equal to annual charges.

Investment costs were allocated to the various interests on the basis of available information including the technical appendices, multiple-purpose project studies, and experience at similar projects.

TABLE 9-20. Program investment costs,[1] Puyallup Basin ($1000)

Feature	Private	Government			Total
		Local	State	Federal	
			1970-1980		
Water Quality Control	420	420	1,230	530	2,600
Flood Control		130	37	18	185
Watershed Management	71,177	53,403	553	10,539	135,672
Fish and Wildlife			403		403
Subtotal	$ 71,597	$ 53,953	$2,223	$11,087	$138,860
			1980-2000		
Water Quality Control	660	660	2,020	860	4,200
Flood Control		70	20	10	100
Watershed Management	47,186	26,432	737	19,768	94,123
Fish and Wildlife			630		630
Subtotal	$ 47,846	$ 27,162	$3,407	$20,638	$ 99,053
			2000-2020		
Water Quality Control	840	840	2,460	960	5,100
Flood Control		70	20	10	100
Watershed Management	67,395	50,568	737	19,564	138,264
Fish and Wildlife			630		630
Subtotal	$ 68,235	$ 51,478	$3,847	$20,534	$144,094
Total	$187,678	$132,593	$9,477	$52,259	$382,007

[1] Cumulative annual program costs over the period.

TABLE 9-21. Project investment costs[1] and cost-benefit summary, Puyallup Basin ($1000)

Feature	Investment Costs					Annual Costs			Annual Benefits	
		Government								
	Private	Local	State	Federal	Total	Interest & Amortization[2]	Operation & Maintenance	Total	Total	Net
			1970-1980							
M&I Water Supply	660	41,403	0	0	42,063	2,061	1,996	4,057	4,057	0
Irrigation	340	0	0	0	340	16	27	43	43	0
Water Quality Control	5,600	13,300	6,650	8,450	34,000	1,590	374	1,964	1,964	0
Navigation[3]	0	2,084	0	3,346	5,430	253	65	318	389	71
Flood Control	0	160	0	1,440	1,600	75	11	86	103	17
Watershed Mgmt.[4]	0	1,947	0	3,025	4,972	232	39	271	382	111
Recreation	8,847	12,386	7,078	7,078	35,389	1,655	684	2,339	3,255	916
Fish & Wildlife	0	0	3,132	174	3,306	155	211	366	849	483
Subtotal	$15,447	$ 71,280	$16,860	$ 23,513	$127,100	$6,037	$3,407	$9,444	$11,042	$1,598
			1980-2000							
M&I Water Supply	900	35,616	0	0	36,516					
Irrigation	680	0	0	0	680					
Water Quality Control	7,200	20,800	10,400	12,800	51,200					
Navigation[3]	0	1,720	0	2,768	4,488					
Flood Control	0	100	0	27,400	27,500					
Watershed Mgmt.[4]	0	1,625	0	2,542	4,167					
Recreation	13,900	19,460	11,120	11,120	55,600					
Fish & Wildlife	0	0	7,629	410	8,039					
Subtotal	$22,680	$ 79,321	$29,149	$ 57,040	$188,190					
			2000-2020							
M&I Water Supply	2,210	57,397	0	0	59,607					
Irrigation	340	0	0	0	340					
Water Quality Control	18,400	29,400	14,700	17,100	79,600					
Navigation[3]	0	0	0	0	0					
Flood Control	0	0	0	0	0					
Watershed Mgmt.[4]	0	0	0	0	0					
Recreation	22,010	30,814	17,608	17,608	88,040					
Fish & Wildlife	0	0	11,517	347	11,864					
Subtotal	$42,960	$117,611	$43,825	$ 35,055	$239,451					
Total	$81,087	$268,212	$89,834	$115,608	$554,741					

1 Capital project costs.

2 Of initial investment and major replacement.

3 Costs and beneifts for pleasure boating moorage facilities included with Recreation.

4 Structural measures installation costs only.

SEQUENCE OF DEVELOPMENT

The projects and programs are summarized in Table 9-22 by time periods. The project numbers identify features on the Basin map, Figure 9-3.

TABLE 9-22. Future projects and programs, Puyallup Basin

PROJECTS PRIOR TO 1980

Municipal and Industrial Water Supply

1. Expansion of Green River supply and transmission system—Tacoma.
2. Expansion of water supply systems—Puyallup, Buckley, Fort Lewis, Orting and other communities.
3.* Increase capacity of self-supplied industrial water systems.

Irrigation

4.* Installation of individual farm irrigation pumping and sprinkler systems (private).

Water Quality Control

5.* Installation of sewerage systems with secondary treatment and disinfection—Orting, Wilkeson, Bonney Lake, Algona, Pacific and Carbonado.
6. Installation of secondary treatment and disinfection—Buckley, Sumner and Puyallup.
7. Installation of secondary treatment, disinfection, adequate outfall and collection facilities—Tacoma.
8. Installation of adequate treatment and adequate outfall—Industry.
9. Secondary treatment, disinfection and adequate outfall—Fort Lewis.

Navigation

10. Deepen Hylebos, Port Industrial and Sitcum Waterways.
11. Small boat harbor development—Hylebos Waterway.
12. Small boat harbor development—Titlow-Day Island.

Flood Control

13. *Construction of levee at Orting.*

Watershed Management

14. Small watershed multiple-purpose project—Algona Pacific.
15. Small watershed multiple-purpose project—Clear Creek.
16. Small watershed multiple-purpose project—Hylebos Creek.
17. Small watershed multiple-purpose project—Wapato Creek.
18. Small watershed multiple-purpose project—Clover Creek.

Recreation

19. Development of six recreation sites along saltwater shoreline.
20. Development of four recreation sites.
21. Development of one recreation site.
22. Development of five recreation sites.
23. Development of three recreation sites along Puyallup River.
24. Development of four recreation sites.
25. Development of three recreation sites.
26. Development of five recreation sites along White River.
27. Development of one recreation site.
28. Development of 30 recreation sites on National Park and Forest lands.

Fish and Wildlife

29.* Acquisition and development of access to eight lakes.
30. Expansion of Puyallup River trout hatchery.
31. Construction of steelhead rearing facilities.
32. Fish passage improvements at Electron Dam and Powerhouse.
33.* Construction of trout hatchery.
34.* Development and acquisition of 40 miles of streambank access.
35.* Acquisition and development of access to five saltwater areas.
36.* Channel and lake clearance.
37.* Acquisition and development of 600 acres of upland bird habitat and hunting area.
38. Expansion of pheasant game farm.
39. Fish passage improvements at White River diversion dam and increased salmon production on White River through artificial propagation facilities.

*Projects not shown on Figure 9-3.

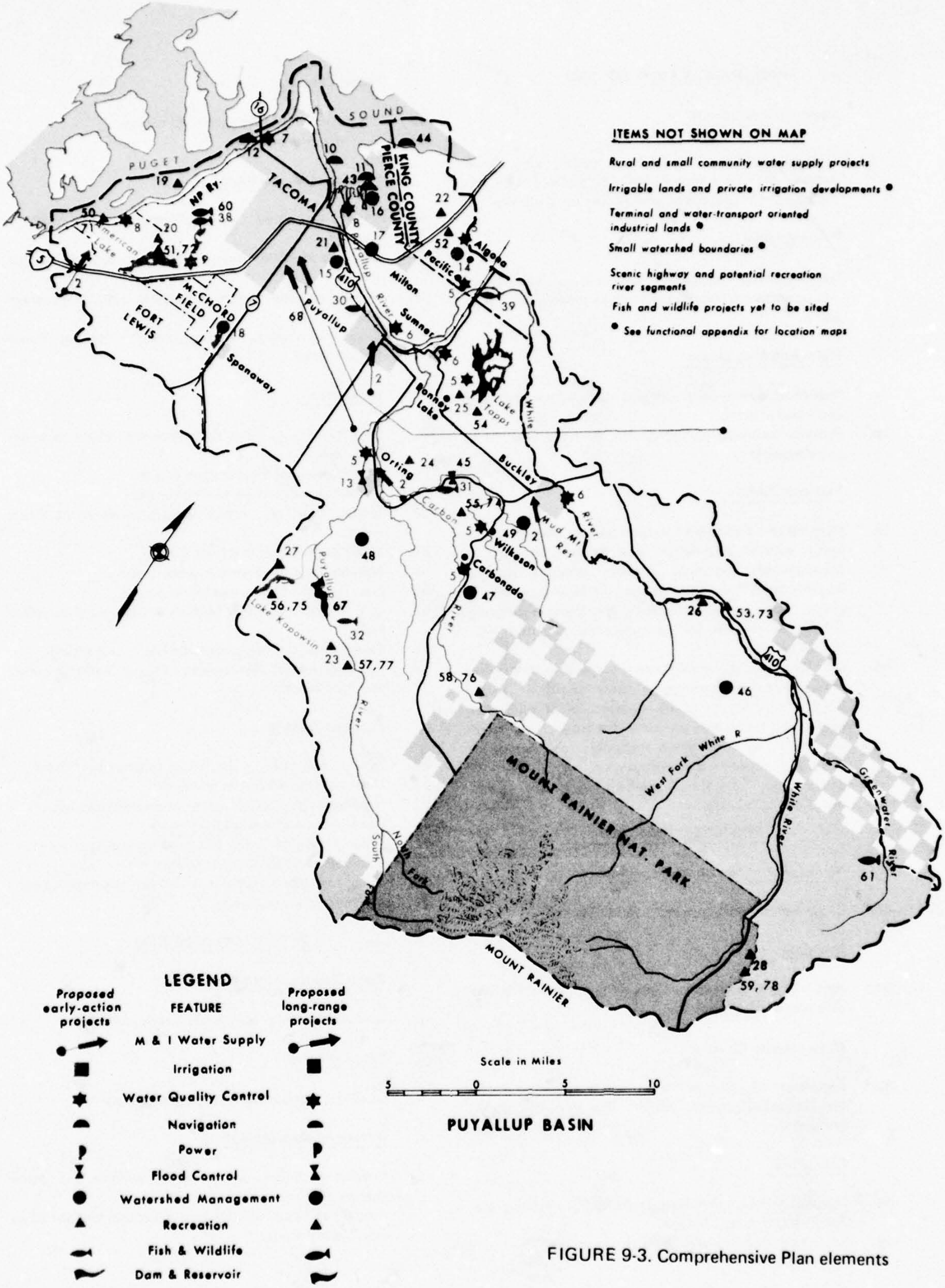


FIGURE 9-3. Comprehensive Plan elements

PROGRAMS PRIOR TO 1980

Water Quality Control

a. Establish and operate water quality surveillance stations at key salt and fresh water locations and prepare comprehensive sewerage plan for the Basin.

Flood Control

b. Establish and administer county-wide flood plain zoning measures under flood plain management program.

Watershed Management

c. Provide technical assistance and management for State and Federal lands.
d. Provide technical assistance for on-farm and other private practices.

Fish and Wildlife

e. Develop lake and stream fertilization techniques.
f. Make wildlife population analysis and timberland management practices studies, develop habitat improvement techniques and an education program on proper game hunting concepts, and begin a program with land owners for game habitat retention and hunter access.
g. Conduct cross-sectional stream surveys to determine minimum and optimum streamflows for fish.
h. Locate, survey, and mark boundaries of all State-owned second class tidelands in the Basin. Take steps to reserve all such lands for public use except as required for specific circumstances.
i. Perform an inventory of shellfish stocks and recreational use of tidelands.

PROJECTS 1980-2000

Municipal and Industrial Water Supply

40.* Expansion of existing water supply systems.

Irrigation

41.* Installation of individual farm irrigation pumping and sprinkler systems (private).

Water Quality Control

42.* Expansion of waste treatment and interception facilities for municipalities, industry and recreation development.

Navigation

43. Deepen Hylebos and Port Industrial Waterways seaward of 11th Street Bridge.
44. Small boat harbor development–Dumas Bay.

Flood Control

45. Construction of levee at South Prairie.
67. Puyallup River storage.

Watershed Management

46. Small watershed multiple-purpose project–White River.
47. Small watershed multiple-purpose project–Carbon River.
48. Small watershed multiple-purpose project–Puyallup River.
49. Small watershed multiple-purpose project–South Prairie Creek.

Recreation

50. Development of three recreation sites along saltwater shoreline.
51. Development of four recreation sites.
52. Development of three recreation sites.
53. Development of six recreation sites along the White River.
54. Development of one recreation site.
55. Development of three recreation sites.
56. Development of one recreation site.
57. Development of three recreation sites along Puyallup River.
58. Development of one recreation site in this vicinity.
59. Development of 20 recreation sites on National Forest and Park lands.

Fish and Wildlife

60. Improvement of salmon passage at Chambers Creek.
61. Clear channel, Green water River.
62.* Improvement of salmon habitat on eight streams.
63.* Construction of a salmon hatchery.
64.* Construction of 1 mile of salmon spawning channel.
65.* Game fish and wildlife improvements.
66.* Lake and channel clearance and habitat improvement on National Forest lands.

PROGRAMS 1980-2000

Water Quality Control

j. Continue water quality surveillance program.

Flood Control

k. Continue flood plain management program.

Watershed Management

l. Provide technical assistance for onfarm and other private practices.
m. Provide technical assistance and management for State and Federal lands.

Fish and Wildlife

n. Continue fish and wildlife programs.

PROJECTS 2000-2020

Municipal and Industrial Water Supply

68. Develop Puyallup River supply for Tacoma.
69.* Expand existing water supply systems.

Irrigation

70.* Installation of individual farm irrigation pumping and sprinkler systems (private).

Water Quality Control

70a.* Expand waste treatment and interception facilities for municipalities, industry and recreation development.

Recreation

71. Develop one recreation site along the saltwater shoreline.
72. Develop two recreation sites.
73. Develop eight recreation sites along White River.
74. Develop four recreation sites.
75. Develop one recreation site.
76. Develop one recreation site.
77. Develop four recreation sites along Puyallup River.
78. Develop 25 recreation sites on National Forest and Park lands.

Fish and Wildlife

79.* Construction of four salmon hatcheries.
80. Development of 16 acres of salmon rearing facilities.
81.* Development of 1 mile of salmon spawning channel.
82.* Game fish and wildlife improvements.
83.* Channel and lake clearance on National Forest lands.

PROGRAMS 2000-2020

Water Quality Control

o. Continue water quality surveillance program.

Flood Control

p. Continue flood plain management program.

Watershed Management

q. Provide technical assistance for onfarm and other private practices.
r. Provide technical assistance and management for State and Federal lands.

Fish and Wildlife

s. Continue fish and wildlife programs.

PLAN ACCOMPLISHMENTS

The Comprehensive Plan accomplishments are summarized by time periods in Table 9-23. As shown, Basin needs are met except for navigation and flood control. Pleasure boating needs cannot be met for the year 2020 in adjacent basins as is planned for the 2000 level of needs. Greater use of dry storage than now desired may partially satisfy the long-range needs for additional moorages.

Flood control needs would significantly be met by a combination of structural and nonstructural measures. Even with these measures residual damages would remain which cannot be economically eliminated.

All watershed management needs would be met as the need arises except water management on urban lands in the 1970-1980 period. However, by the year 2000 this need would be fully met.

All fish and wildlife needs would be met by 1980 with opportunities outside the area or by hunters accepting a lower success ratio in future years assumed. Some improvements in fish production could result from low flow augmentation from the storage on the Puyallup River after 1980.

ALTERNATIVE ELEMENTS

Alternative measures to those elements contained in the Comprehensive Plan and reasons for not adjusting these alternatives are discussed in this section.

Alternative to Municipal and Industrial Water Supply Elements

Currently, desalinization is too expensive to make the use of salt water competitive with fresh water sources. Surface water supplies are more than adequate for projected municipal and industrial needs, assuming continued availability of the Green River. Extensive ground water aquifers of good quality and unknown capacity are used mainly as a source of supply when Green River water is wasted into the Puyallup River because of turbidity. Ground

TABLE 9-23. Comprehensive Plan accomplishments, Puyallup Basin

Feature	Units	To 1980			To 2000			To 2020		
		Needs	Accomp.	Residual	Needs	Accomp.	Residual	Needs	Accomp.	Residual
M&I Water Supply	mgd	85.7	85.7	0	228.3	228.3	0	446.9	446.9	0
Irrigation	1000 Acre-Feet	5.9	5.9	0	17.7	17.7	0	23.7	23.7	0
Water Quality Control										
Waste	1000 Population Equivalents	1,063	1,063	0	2,013	2,014	0	3,019	3,019	0
Flow	cfs[1]	105	105	0	245	245	0	270	270	0
Navigation										
Commercial	1000 Short Tons	3,700	3,700	0	14,000	14,000	0	17,200	17,200	0
Pleasure Boats	Wet Moorages	3,000	1,550	1,450[3]	7,100	5,720	1,380[4]	15,050	5,720	9,330[4]
Power[2]										
Flood Control	$1000 Damage Reduction	151	123	28	301	275	26	602	339	263
Watershed Management										
Flood Prevention	1000 Acres	48.1	48.1	0	48.1	48.1	0	48.1	48.1	0
Watershed Protection and Rehabilitation	1000 Acres	759.0	759.0	0	759.0	759.0	0	759.0	759.0	0
Water Management[5]										
Agricultural	1000 Acres	12.0	12.0	0	19.9	19.9	0	26.6	26.6	0
Urban	1000 Acres	123.2	82	41.2	123.6	123.6	0	198.5	198.5	0
Recreation	1000 User-Days	3,100	3,100	0	7,800	7,800	0	16,100	16,100	0
Fish and Wildlife										
Sport										
Fishing	1000 User-Days	492	492	0	1,250	1,250	0	2,476	2,476	0
Hunting	1000 User-Days	69	69	0	159	159	0	213	213	0
Commercial Fishing	1000 Pounds	108	108	0	1,928	1,928	0	4,278	4,278	0

1 Puyallup River.

2 Power needs were projected for the Puget Sound Area only.

3 Residual wet moorage needs assumed to be satisfied by private developments.

4 Wet moorages needs satisfied in the Nisqually-Deschutes Basins.

5 Needs and Accomplishments are cumulative.

6 Approximately 1,900 of residual wet moorage needs satisfied in Nisqually-Deschutes Basins.

water supplies could be more fully developed for continuous as well as emergency use. Thorough explorations of the Basin ground water reserves should be made to obtain information needed for planning the most economic future expansion of an integrated water supply and treatment system.

The single-purpose municipal and industrial water supply plan from Appendix VI, incorporated in the Comprehensive Plan, includes diversion from the Puyallup River after 2020 to supplement the Green River and ground water sources. Puyallup River flows in the lower reaches, with treatment, are adequate to serve demands until 2020 and leave sufficient low flow to meet minimum water quality standards for the stream. However, such use would reduce natural flows and impair anadromous and resident fish spawning and rearing. Also, augmentation is needed for existing natural low flows to enhance the natural fish environment. A full evaluation of the effects of municipal and industrial withdrawals as well as possible augmentation benefits from storage awaits completion of stream surveys and research. After completion of these investigations, a full evaluation of all costs and benefits relating to fish and water supply may reveal that the most efficient use of the Puyallup River water would dictate the use of storage. Such provision could be made in the Puyallup River storage project. Another site available for multiple-purpose storage is the South Prairie Creek site selected for flood control in Appendix XII, Flood Control. This project was not included in the Comprehensive Plan due to environmental considerations.

Alternatives to Flood Control Elements

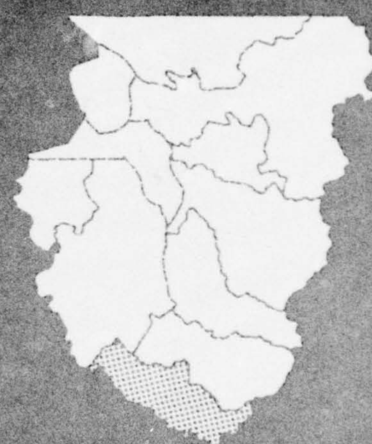
Single and multiple-purpose flood storage, channel and levee improvements, were investigated in developing the Comprehensive Plan. The combination considered most economical has been selected. However, more detailed investigations than were possible under the time and fund limitations of this study would be required for project authorization. Such investigations would include detailed site examinations including foundation explorations of the selected site; storage evaluations in connection with desired flood control, power and conservation operation; valley and stream cross-sectional surveys, flood routings and flood damage prevention estimates for various combinations of dam and levee designs. Floodproofing of existing structures might find economic application in isolated instances, but would also be an infeasible substitute for the proposed measures. Relocation of flood-damageable structures to high ground also was found to be uneconomical.

Alternative to Fish and Wildlife Elements

Proposed fish and wildlife measures would provide for increasing recreational fishing, hunting and commercial fishing opportunities. All potential means for increasing fish and game production in the Basin have been considered. Measures to increase natural fish habitat productiveness have been weighed against hatchery production, and both are included in the Plan to provide the most economic overall solution to the problem of economically meeting recreational and commercial needs. The fish and wildlife improvements which can most quickly and efficiently increase productivity are placed in the earlier schedules. The benefits of low streamflow augmentation from storage remains to be evaluated.

There is a possibility that Mud Mountain Dam can be operated to provide increased low flows in the White River for fish. However, neither cost of downstream fish passage facilities nor the value of low flow augmentation is known and must be evaluated before a final decision can be made on the change in project operation. Additional transportation water also could be made available by a reduction in water diversion by Puget Sound Power and Light. This matter is to be considered by the Federal Power Commission during relicensing proceedings.

Nisqually-Deschutes Basins



NISQUALLY—DESCHUTES BASINS

DESCRIPTION OF BASINS

GENERAL

The Nisqually-Deschutes Basins encompass a gross area of 1,008 square miles of land, 17 square miles of fresh water, and 13 square miles of marine waters with 75 miles of shoreline within the Basins. The drainage areas of the Nisqually and Deschutes Rivers are 712 and 162 square miles, respectively.

The Basins have an average annual runoff of 1,557,000 acre-feet with the Nisqually River contributing 1,272,000 acre-feet (at McKenna), and the Deschutes River contributing 285,000 acre-feet (near Olympia). Significant ground water aquifers lie under a 570 square mile plain. These aquifers receive an estimated 200,000 acre-feet recharge in an average year.

The orographic lifting of moist maritime air on the windward foothill Cascade Mountains results in an annual precipitation from about 40 inches to more than 120 inches at Mount Rainier. Average annual snowfall ranges from less than 15 inches at the low elevations to 582 inches at Paradise Ranger Station.

Streamflow characteristics and other data related to hydrology of the Basin are discussed in detail in Appendix III, Hydrology and Natural Environment. The physiographic characteristics are discussed in more detail in Appendix V, Water-Related Land Resources.

PRESENT SITUATION

Local Economy

The 1967 population estimate for the Basins was 70,100. The principal population centers are Olympia with 20,880, Tumwater 4,698, and Eatonville 900. The remaining population are located in rural nonagricultural and agricultural communities throughout the northwestern half of the Basins. Population changes in the Basins and the principal population centers are projected in Table 10-1.

TABLE 10-1. Historical population, Nisqually-Deschutes Basins

	1940	1950	1960	1967
Nisqually-Deschutes				
Basins	39,600	48,600	59,300	70,100
Principal cities and towns:				
Olympia	13,254	15,819	18,273	20,880
Tumwater	--	--	3,885	4,698
Eatonville	996	1,048	896	900
Yelm	378	470	479	525
Rainier	--	331	245	311

Source: Appendix IV, Economic Environment, Appendix V, Water-Related Land Resources.

Lumbering and forest products are the Basins economic mainstays. Mining, farming, fishing, metalcraft, boat building, cold storage, meat packing, and a major brewery give the Basins a diversified commercial base.

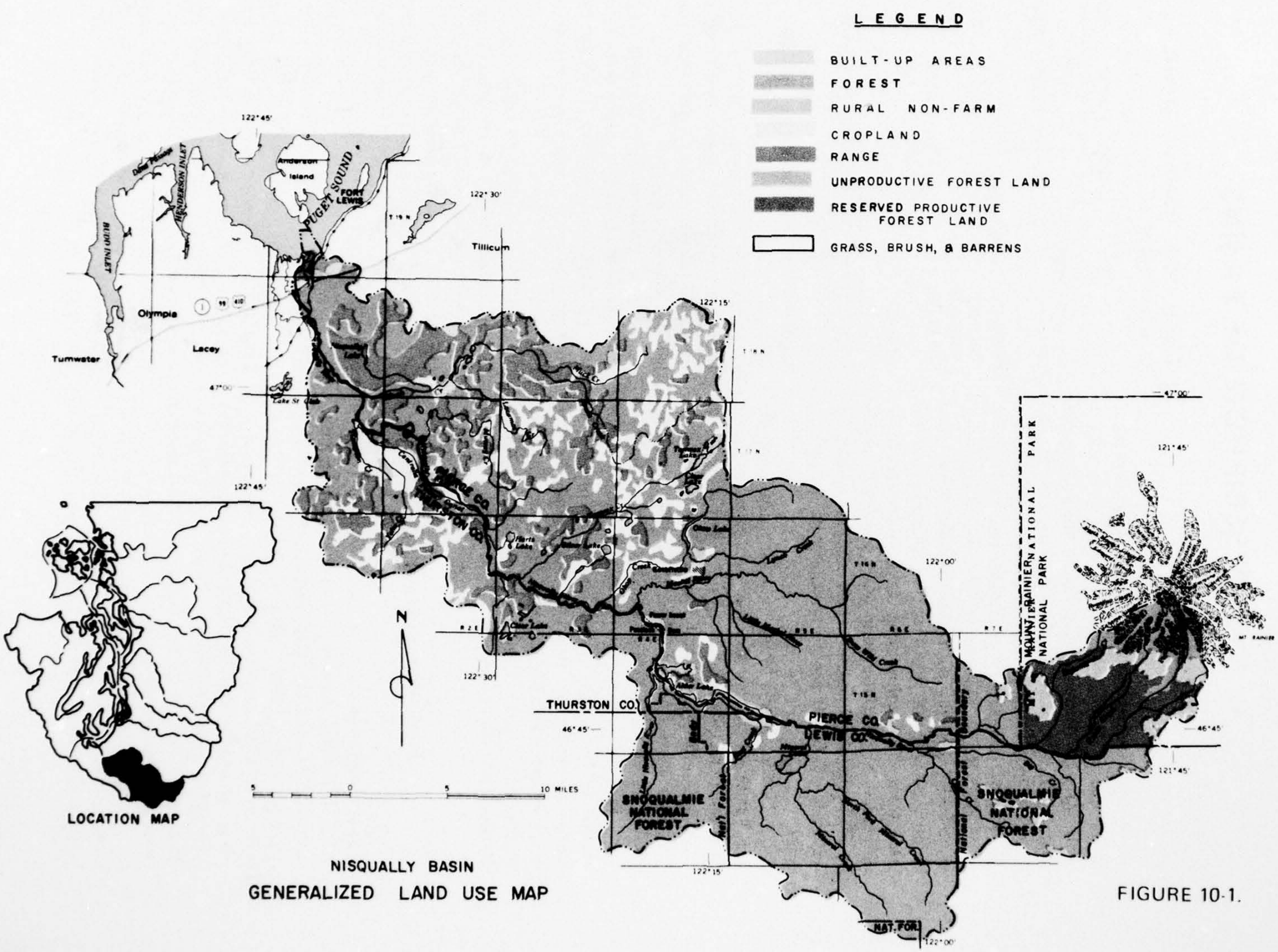
The Port of Olympia at Budd Inlet is equipped to handle cargo from ocean vessels and local water freight. Industrial plants occupy approximately one-half of the port property.

Farms are intensively managed to yield high-value products. Livestock raising is the most common and valuable farm industry. Dairying, berries, and poultry play an important part in the agricultural economy.

With the capital at Olympia, State government is the largest employer in Thurston County. In 1963, government accounted for nearly 36 percent of total employment. Manufacturing also plays a leading role, but increases in employment in this sector have been gradual, and averaged slightly more than 3 percent during the decade, 1954-1964.

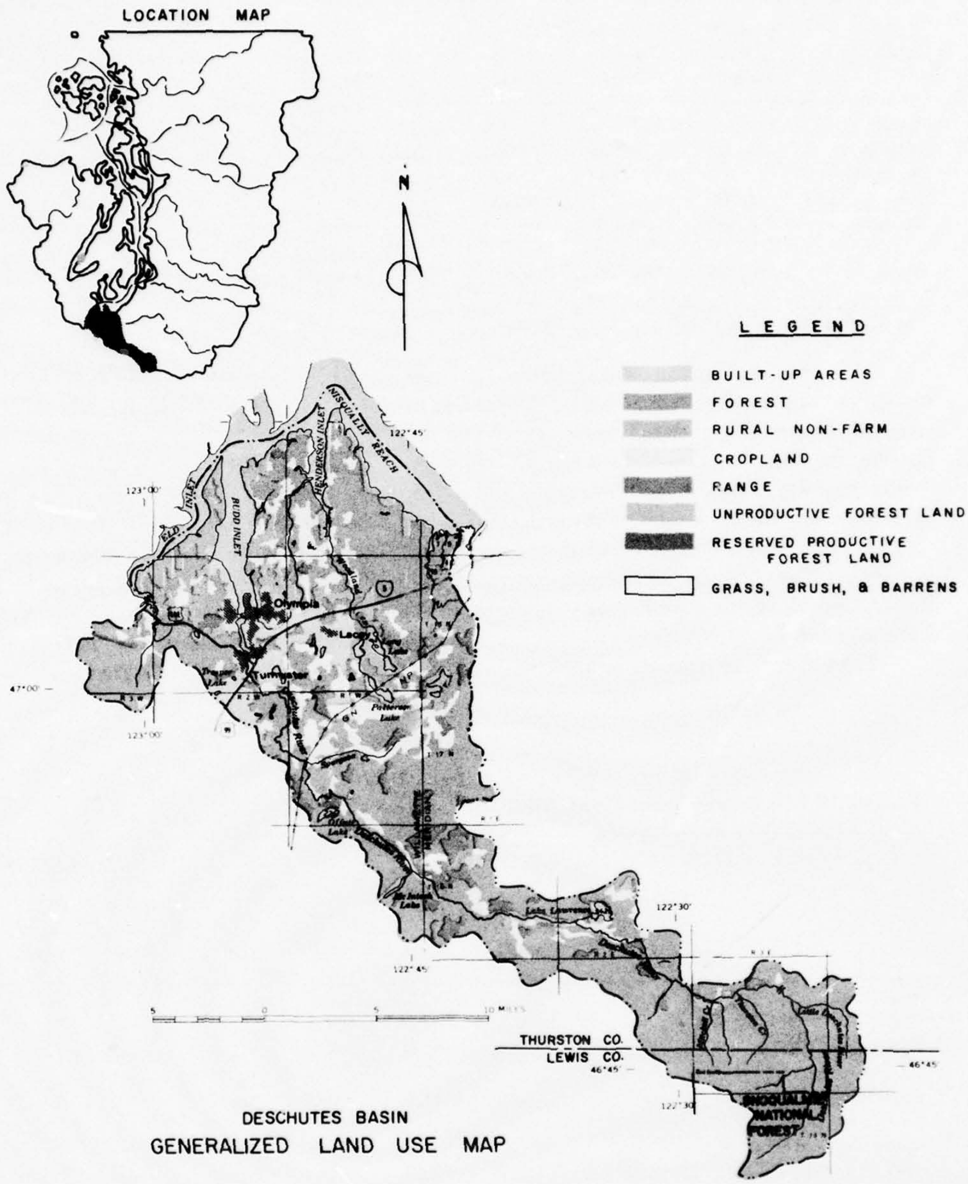
Land Use

Within the Nisqually-Deschutes Basins the land area is 635,600 acres and the fresh water area is 10,100 acres, making a total of 645,700 acres of land and fresh water. A tabulation of the 1967 land use categories indicate that 94 percent of the land area is in agricultural use, and 3 percent each in rural nonagricultural and intensive use. The land use is tabulated in Table 10-2 and shown on Figure 10-1 and 10-2.



NISQUALLY BASIN
GENERALIZED LAND USE MAP

FIGURE 10-1.



DESCHUTES BASIN
GENERALIZED LAND USE MAP

FIGURE 10-2.

TABLE 10-2. Present land use, Nisqually-Deschutes Basins

Land Use	Nisqually Basin (acres)	Deschutes Basin (acres)	Basins Total (acres)	Percent
Forest	379,700	127,100	506,800	80.0
Rangeland	34,000	9,500	43,500	6.8
Cropland	29,200	16,300	45,500	7.1
Rural nonfarm	6,400	13,500	19,900	3.1
Intensive	5,500	14,400	19,900	3.0
Total	455,800	180,800	635,600	100.0

Source: Appendix V, Water-Related Land Resources.

The intensive, urban and built-up land use categories consist of residential, industrial, public and semi-public uses and reserved open space. The use distribution is tabulated in acres as follows: railroads, 1,500; roadways, 5,000; airports, 500; and urban (built-up), 12,000 for a total of about 19,000 acres.

The areas of intensive development are in the vicinity of Olympia, Tumwater, Eatonville, Yelm, Rainier and along the shoreline of Henderson, Budd and Eld Inlets.

Land ownership is shown in Table 10-3.

TABLE 10-3. Land ownership, Nisqually-Deschutes Basins

Ownership	Percent
Private	41
Private corporate	28
Federal	20
State	10
Local government	1
Total	100

Source: Appendix V, Water-Related Land Resources.

PROJECTED ECONOMY AND LAND USE

Local Economy

The future economy of the Basins is expected to continue the present type of development. The projected growth of the Western Division is shown in Table 10-4. Although the Nisqually Basin is partially in the Western Division, its projected economy parallels the Deschutes and therefore would be included in the Western Division.

TABLE 10-4. Economic projections, Nisqually-Deschutes Basins

	1963	1980	2000	2020	Average Annual Growth Trends (Percent) 1963 to 1980	1980 to 2000	2000 to 2020	1963 to 2020
West Division								
Population (1000's)	116.0	122.5	168.5	232.4	0.3	1.7	1.6	1.2
Employment (1000's)	37.7	41.9	57.6	79.5	0.6	1.6	1.6	1.3
Gross Regional Product ($1,000,000)	290.0	498.0	1,066.0	1,329.0	3.2	3.9	1.1	2.7
Nisqually-Deschutes								
Population (1000's)	69.6	81.9[1]	104.5	146.5	0.6	1.7	1.7	1.3

[1] Increased by 7,000 persons to reflect the new Evergreen State College presently under construction.

Source: Appendix IV, Economic Environment, Appendix V, Water-Related Land Resources.

Major growth strength would be in the wood products industry, particularly by 1980. While some employment would drop off in agriculture and lumber, growth would be experienced in the services, wholesale and trade, construction and government.

The new Evergreen State College which is presently under construction at Olympia, is expected to cause a significant impact upon the Basin prior to 1980. The college is expected to bring 7,000 additional persons into the Olympia area during this time period.

Further economic projections by industry can be obtained from Appendix IV.

Future Land Use

The land use for the Basin as projected for alternative C_2 in Appendix V, Water-Related Land Resources, indicates intensive land use areas by 2020 would displace 1,000 acres of forest, 2,200 acres of rural nonfarm, 200 acres of cropland, and 200 acres of grassland for a total displacement of 3,600 acres. The change of land use is tabulated in Table 10-5 and shown on Figures 10-3 and 10-4.

Land is intensively used in and around the city of Olympia and several of the smaller communities. A large part of this use is residential development to serve increasing numbers of persons employed by State government and personnel build-up at the Fort Lewis Military Reservation. Indications are that State government would continue to increase, especially after 1970. Also, development of Evergreen State College would create the need for additional intensive land use.

TABLE 10-5. Present and projected[1] land use, Nisqually-Deschutes Basins (acres)[2]

Land Use	1967	1980	2000	2020
Forest	506,800	507,000	506,500	505,800
Range	43,500	43,500	43,400	43,300
Cropland	45,500	45,500	45,400	45,300
Rural nonfarm	19,900	18,800	17,600	17,700
Intensive	19,900	20,800	22,700	23,500
Total	635,600	635,600	635,600	635,600
Population (1000's)	70.1	81.9[3]	104.5	146.5
Density[4]	3.0	3.9	4.6	6.2

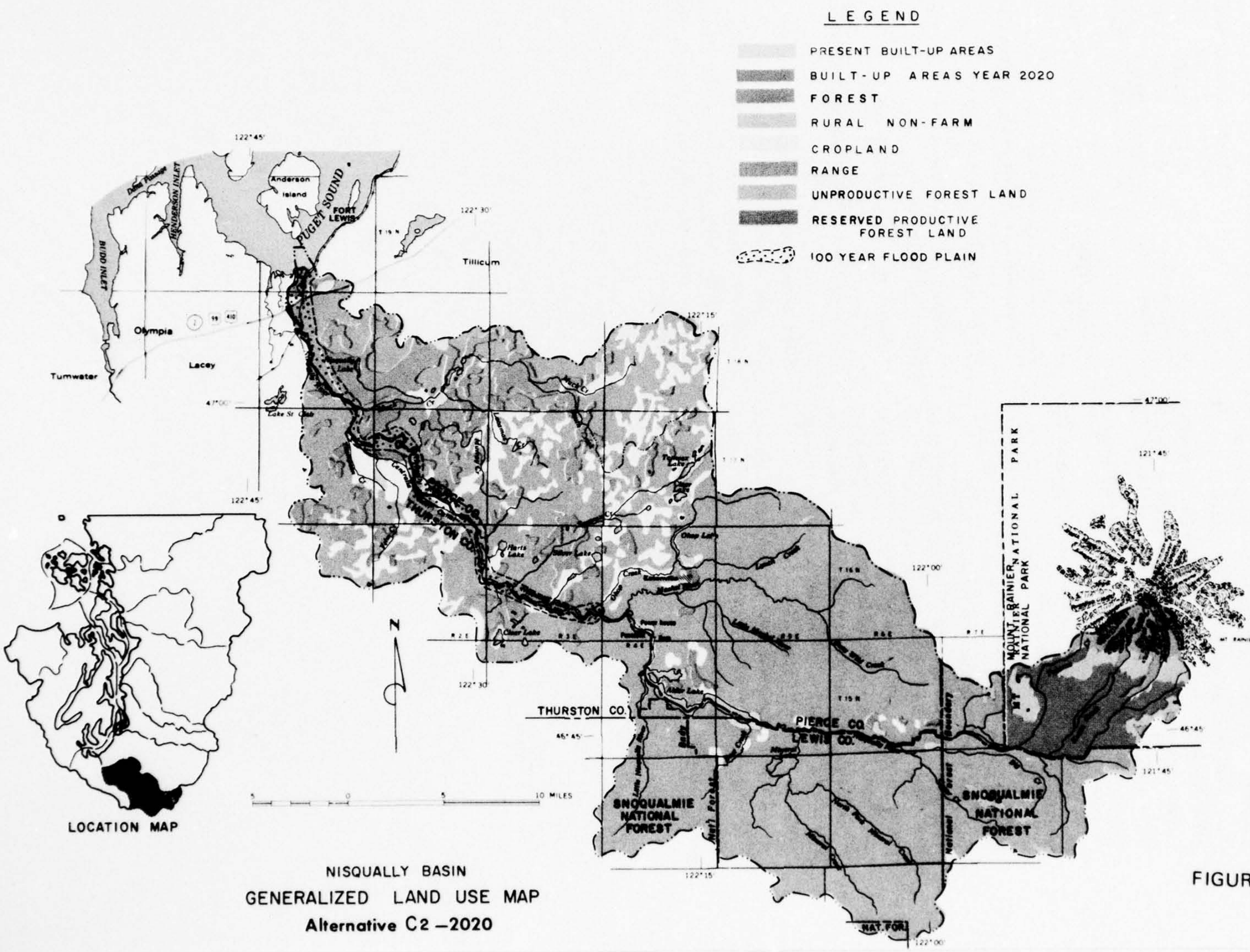
1 Alternative land use pattern C_2, see Puget Sound Area.

2 Figures rounded to nearest hundred.

3 Increased by 7,000 persons to reflect impact of new Evergreen State College.

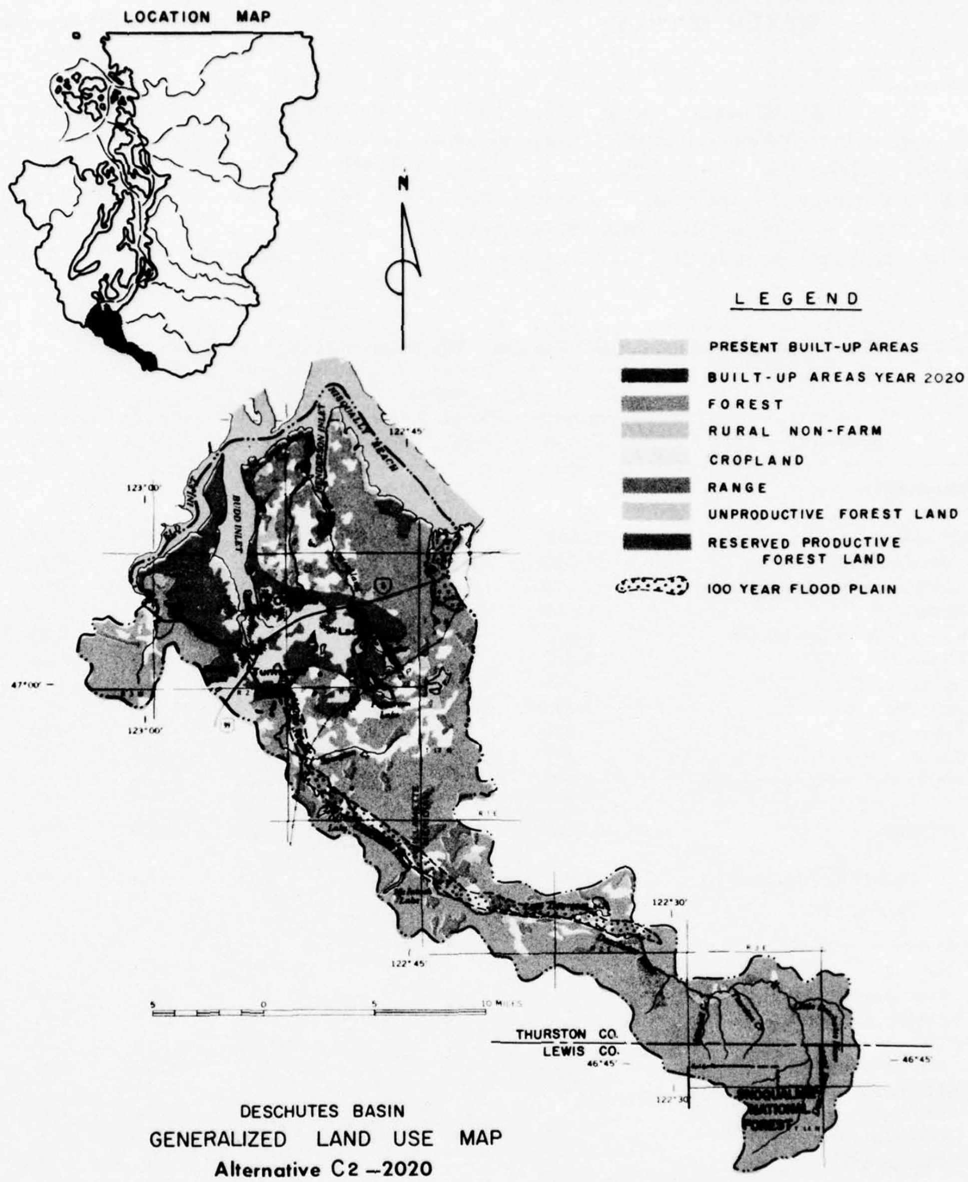
4 Persons per intensive land use acre.

Source: Appendix V, Water-Related Land Resources.



NISQUALLY BASIN
GENERALIZED LAND USE MAP
Alternative C2 – 2020

FIGURE 10-3.



DESCHUTES BASIN

GENERALIZED LAND USE MAP

Alternative C2 –2020

FIGURE 10-4.

WATER AND RELATED LAND RESOURCE NEEDS

MUNICIPAL AND INDUSTRIAL WATER SUPPLY

General

Nearly all municipal and industrial water systems in both Basins are supplied from various ground sources. The city of Olympia, the largest municipal water user in the Basins, obtains its present water supply of 2.80 mgd from McCallister Springs which can supply 30 mgd. The cities of Lacey and Tumwater obtain their water supplies from ground water aquifers which underlie the cities. The communities of Paradise and Longmire in the Nisqually Basin obtain their supplies from surface sources. Eatonville is converting to infiltration wells along the Nisqually River which is considered a surface source. Industrial water use is not extensive and is provided through the city of Olympia's system or is self-supplied.

Water use in the year 1965 is shown in Table 10-6.

TABLE 10-6. Municipal and industrial water use, 1965, Nisqually-Deschutes Basins

System	Estimated Population Served	Surface Water Usage (mgd) Average Daily	Surface Water Usage (mgd) Maximum Monthly	Surface Water Usage (mgd) Maximum Daily	Ground Water Usage (mgd) Average Daily	Ground Water Usage (mgd) Maximum Monthly	Ground Water Usage (mgd) Maximum Daily
MUNICIPAL USE							
Olympia	22,632	--	--	--	2.80	4.70	6.70
McKinley Water Co., Inc.	(1,000)	--	--	--	(0.14)	(0.27)	(0.41)
West Conger Water Supply Co.	(63)	--	--	--	(0.01)	(0.02)	(0.02)
Paradise	4,500	0.20	0.23	0.26	--	--	--
Huntaner-Water Service, Inc.	4,500	0.10	0.20	0.30	0.20	0.90	1.70
Tumwater	4,450	--	--	--	0.60	1.20	1.80
Longmire	1,200	0.08	0.10	0.13	--	--	--
Eatonville	1,000	0.20	0.70	1.20	--	--	--
Yelm	795	--	--	--	0.10	0.20	0.25
Rainier	300	--	--	--	0.01	0.02	0.03
Other rural community systems	6,645	0.02	0.03	0.04	1.03	1.64	2.11
Subtotal	46,022	0.60	1.26	1.93	3.48	8.66	12.59
RURAL-INDIVIDUAL USE[1]	22,911	0.13	0.18	0.26	1.13	1.60	2.26
INDUSTRIAL USE							
Municipally supplied:							
Olympia							
Food and kindred		--	--	--	0.12	0.12	0.12
Lumber and wood		--	--	--	0.40	0.50	0.60
Yelm							
Food and kindred		--	--	--	0.02	0.02	0.02
Self-Supplied:							
Food and kindred		--	--	--	1.40	1.70	2.00
Stone, clay, glass		0.24	0.24	0.24	--	--	--
Other sources		--	--	--	0.04	0.05	0.06
Subtotal		0.24	0.24	0.24	2.00	2.40	2.80
Total[2]	68,933	1.00	1.70	2.40	6.60	12.70	17.60

[1] Estimated 90 percent of rural-individual population supplied by ground water.

[2] Figures are rounded.

Source: Appendix VI, Municipal and Industrial Water Supply.

Present and Future Needs

The population growth is projected to increase to 146,500 by the year 2020 resulting in a maximum monthly water requirement of approximately 56 mgd by that time. This would be an increase of about 400 percent over present use.

Most of the increase is expected to occur in and around the Olympia urban area. Projected municipal and industrial water needs are summarized in Table 10-7.

The population projected for 1980 in the Deschutes Basin has been increased by 7,000 to recognize the growth anticipated for Evergreen State College. The water requirements have been adjusted accordingly. Additional water supplies would be needed in the greater Olympia area prior to 1980.

The Olympia area lies in a broad ground water area with eight sub-areas economically available for development of good quality water. Six are within or near urban centers. Extensive testing would be required to learn the true potential of each area, but there appears to be a potential for upwards of 100 mgd from these ground water areas for the future needs of Olympia, Lacey and Tumwater.

TABLE 10-7. Projected municipal and industrial water needs, Nisqually-Deschutes Basins

Year	Use	Total (Average Daily M.G.D.)	Total (1000's Acre-Feet Annually)	Net Needs[1] (M.G.D.)	Net Needs[1] (1000's Acre-Feet)
1965	Municipal	4.1	4.6		
	Industrial	2.2	2.4		
	Rural-Individual	1.3	1.5		
	Total	7.6	8.5		
1980	Municipal	11.4[2]	12.8		
	Industrial	3.1	3.5		
	Rural-Individual	1.6	1.8		
	Total	16.1	18.1	8.5	9.6
2000	Municipal	16.4	18.3		
	Industrial	5.8	6.5		
	Rural-Individual	2.3	2.5		
	Total	24.5	27.3	16.9	18.8
2020	Municipal	26.9	30.0		
	Industrial	11.0	12.3		
	Rural-Individual	3.2	3.6		
	Total	41.1	45.9	33.5	37.4

[1] Cumulative total above 1965 use.

[2] Includes additional 1.4 mgd for Evergreen State College.

Source: The needs are based upon population and industrial growth as projected in Appendix IV, Economic Environment, and do not reflect population adjustments shown in Appendix VI, Municipal and Industrial Water Supply.

IRRIGATION

General

Arable lands in the Basins total 48,850 acres, of which 5,580 are presently irrigated. Irrigation development is scattered and is located throughout the lower elevations of the Basins. The largest concentrations are found south of Olympia and in the vicinity of Yelm. Irrigated lands are generally located in areas with easily available water supplies.

Present and Future Needs

Potentially irrigable lands total about 43,300 acres of which 23,500 are in the Nisqually Basin and 19,800 are in the Deschutes Basin. Projections are that about 14,600 acres of new lands in the Nisqually Basin and 600 acres in the Deschutes River Basin would be under irrigation by the year 2020. The projections are shown in Table 10-8.

TABLE 10-8. Irrigation present status and projected needs, Nisqually-Deschutes Basins

Year	New Irrigation (acres)	Total Irrigation (acres)	Total Annual Diversion (ac. ft.)	Net Needs[1] (ac. ft.)
1966	--	5,600	13,300	--
1980	2,200	7,800	18,500	5,200
2000	5,000	12,800	30,400	17,100
2020	8,000	20,800	49,300	36,000

[1] Cumulative diversion above 1965.

Source: Appendix VII, Irrigation.

It is expected that the projected surface divisions would be mostly from the tributary streams of the Nisqually and Deschutes Rivers.

The monthly distribution of the irrigation requirements are:

May	4%	July	31%	September	14%
June	21%	August	30%	Total	100%

WATER QUALITY CONTROL

General

The chemical quality of the Nisqually and Deschutes Rivers is excellent. The waters are soft, low in dissolved solids, and high in dissolved oxygen concentrations. The Nisqually River carries a significant sediment load, averaging between 250,000 to 300,000 tons annually. Nearly all of this sediment settles out in Alder Reservoir.

The raw municipal and industrial wasteload now approximates 120,800 PE,[1] of which 20 percent is removed by waste treatment before being discharged to fresh and marine waters. The largest quantity of waste is discharged into Budd Inlet. Sources of waste in the Basins are summarized in Table 10-9.

The community of Eatonville discharges 100 PE daily to the Mashell River, a tributary of the Nisqually River. This is the only waste discharge to fresh water which exists in the Basins.

Present and Future Needs

State-Federal water quality standards provide the baseline from which present and future needs for water quality control are determined. The water quality classification established by the State for each watercourse in the Basin are outlined in Appendix XIII, Water Quality Control. Present and future water quality control needs are for compliance with objectives defined in the State standards.

Present water quality control needs are concentrated primarily in Budd Inlet where municipal and industrial waste discharges create unsatisfactory water quality conditions. Water quality objectives for dissolved oxygen, bacteria, aesthetics and toxics, are not being met here.

The major sources of waste to these waters are the cities of Olympia and Tumwater. Municipal and industrial wastes which receive primary treatment before discharge into the rather shallow waters of Budd Inlet, are primary cause of poor water quality in this area.

High coliform counts at the mouth of the Deschutes River during each summer's low flow period show it to be unsatisfactory from a Public Health standpoint. This bacterial contamination should be controlled.

The rapid growth of Lacey, and its parallel increasing subsurface domestic waste discharges through septic tank units, poses a possible threat to the bacterial quality of the ground water.

TABLE 10-9. Summary of municipal and industrial wastes, Nisqually-Deschutes Basins, 1965

Receiving Water	Estimated Population Served 1965	Nonseasonal Untreated Waste PE	Seasonal Untreated Waste PE	Treatment	Nonseasonal Waste Discharge PE	Seasonal Waste Discharge PE
Nisqually River						
Paradise	800	1,000	--	Primary	0	--
Longmire	800	1,000	--	Primary	0	--
Mashell River						
Eatonville	700	900	--	Lagoon	100	--
Henderson Inlet						
Woodland Creek						
St. Martins Coll	300	350	--	Lagoon	0	--
Food and kindred	--	200	--	None	200	--
Budd Inlet						
Olympia	22,000	49,000	--	Primary	34,500	--
Lumber and wood	--	1,400	--	None	1,400	--
Food and kindred	--	900	--	None	900	--
Tumwater	4,000	6,000	--	Olympia	5,500	--
Food and kindred	--	60,000	--	Olympia	55,000	--
TOTAL[1]	28,600	120,800	--	--	97,600	--
Municipal	--	58,300	--	--	40,100	--
Industrial	--	62,500	--	--	57,500	--

[1] Figures are rounded.

Source: Appendix XIII, Water Quality Control.

Present and future wasteloadings are projected to be as shown in Table 10-10.

TABLE 10-10. Present and projected raw wasteloadings, Nisqually-Deschutes Basins (1000's PE)

Year	Municipal	Industrial	Recreational	Total	Net Needs[1]
1965	58	63	18	139	116
1980	66	92	30	189	166
2000	98	183	56	338	315
2020	147	336	102	584	561

[1] Cumulative raw wasteload requiring treatment above that receiving treatment in 1965.

Source: Appendix XIII, Water Quality Control.

Future wasteloadings on the Nisqually and Deschutes Rivers are projected to be light and the minimum flows for other uses such as fish should be sufficient to maintain desirable water quality. Future growth of population and industry would be concentrated in the Olympia-Tumwater area. Future wastes produced in this area would be treated before discharged into Budd Inlet. The primary needs would be to provide adequate collection and treatment facilities as population expansion occurs.

NAVIGATION

General

The major harbor development in the Basins is Olympia Harbor located at the head of Budd Inlet, 168 nautical miles from the Pacific Ocean. Although the northerly part of Budd Inlet has depths of over 40 feet, the southerly portion at the head of the inlet is quite shallow. Dredging is presently required in the southerly section of Budd Inlet to maintain a 30-foot deep channel and turning basin. Minor harbors in the Basins include a railroad log dump on the west side of Henderson Inlet and at Boston Harbor in Boston Cove.

In 1963 there were about 51 acres in use for terminal facilities, about 7 acres for vessel repair and construction, and 76 acres for other water-oriented industries.

In 1966 small boat harbors and related facilities on salt water contained a total of 520 wet moorages which could accommodate all year use.

Present and Future Needs

The major problem in Olympia Harbor is the requirement for periodic dredging to remove the silt brought in by the Deschutes River and by the tidal currents in Budd Inlet. The port has potential for further development but its physical boundaries of 510 acres are a limiting factor to its expansion.

The Basins are expected to experience a modest increase in general cargo and forest products. Improvement of existing facilities and development of additional areas would be required to meet these needs.

Although no large increase in tonnages are foreseen for Olympia Harbor, it would be necessary to increase the present channel depth from the present 30-foot depth to 40 feet by 1980 to handle the larger draft vessels entering Puget Sound.

To meet the future port and related land area needs, a new harbor with additional terminal and storage space would be required around the year 2000. Site locations at Hawks Prairie and the Nisqually Delta are considered adequate to meet these needs. The acreage available for expansion in these areas are shown in Table 10-11.

TABLE 10-11. Harbor and channel and terminal and water transport-oriented industrial land use, Nisqually-Deschutes Basins

	Harbor and Channel Reg. (vessel draft in feet)			*Terminal and* Industrial Land (acres)	
Year	Freighters	Bulk Carriers	Tankers	Total	Net Needs[1]
1963	--	--	--	134	--
1980	35	--	--	310	176
2000	40	71	--	2,250	2,116
2020	40	71	--	3.760	3,626

[1] Cumulative needs above 1963 land use.

Source: Appendix VIII, Navigation.

The Basins contain large and well protected inlets suitable for locating small boat harbors. With the population expansion projected for the southern part of Puget Sound there would be a substantial increase in demand for small boat facilities.

The projected small boat moorage needs and waterborne commerce are shown in Table 10-12.

TABLE 10-12. Projected pleasure boating needs and waterborne commerce, Nisqually-Deschutes Basins

	Small Boat Wet Moorages			Waterborne Commerce (1000's Short Tons)	
Year	Total	Net Needs[1]	Year	Total	Net Needs[2]
1966	1,000	480	1963	800	--
1980	1,170	650	1980	1,000	200
2000	1,950	1,430	2000	6,000	5,200
2020	2,700	2,180	2020	24,300	23,500

[1] Cumulative needs above the 520 wet moorages available in 1966.

[2] Cumulative waterborne commerce above total for 1963.

Source: Appendix VIII, Navigation.

POWER

General

Tacoma City Light has two hydroelectric projects on the Nisqually River. Alder, with an installed capacity of 50,000 kw and a reservoir with 180,000 acre-feet of usable storage, is the upstream plant. LaGrande, the lower plant, has an installed capacity of 64,000 kw and a pondage reservoir of 2,700 acre-feet.

The city of Centralia diverts 720 cfs about 11 miles below LaGrande Dam, into a power canal for 9 miles to its Yelm hydroelectric power plant which has an installed capacity of 9,000 kw. The diversion by-passes about 13 miles of the main-stem and is returned directly to the Nisqually River.

The National Park Service has the Paradise hydroelectric project, in Rainier National Park. The project, sometimes called Longmire, has an installed capacity of 800 kw. About 33 cfs is diverted from Paradise River for approximately 1 mile for operation of the plant and then returned to the river.

No power regulation or storage exists on the Deschutes River.

Present and Future Needs

There are no economically feasible single-purpose hydropower site locations within the Basins.

Meeting the future power needs in the Basin, as in all of the Puget Sound Area, would require the addition of thermal-nuclear power plants and pumped-storage hydroelectric plants. These needs are discussed in the Area portion of this Appendix and in Appendix IX, Power.

FLOOD CONTROL

General

Overbank flooding occurs frequently along the Nisqually River above Alder Reservoir. Overbank flooding along the river below Alder Reservoir occurs on a frequency of about once every seven years and damage begins when flows exceed 18,000 cfs at the gage near McKenna. Along the Deschutes River flooding occurs on a frequency of about once every two years. Flooding is minor along the tributary streams of both Basins and generally result from poorly defined channels.

Small levees along both the Nisqually and Deschutes Rivers provide moderate protection to small areas adjacent to the rivers. There is no reservoir flood control storage on either river although Alder and LaGrande Reservoirs do provide some flood protection when the reservoir is not full.

The levees presently being constructed along Lower Deschutes River at Tumwater would provide 50-year protection to the adjacent low lying urban areas.

Table 10-13 lists the peak discharges and recurrence intervals of recent major floods and projected probable 50 and 100-year floods at McKenna on the Nisqually River and Olympia on the Deschutes River. Estimated flood damages are based on 1966 prices and conditions.

Present and Future Needs

The 9,000-acre Nisqually River and the 2,700-acre Deschutes River flood plains need increased flood protection for existing developments. Present levees were constructed piecemeal by private land-owners to alleviate localized flooding, and are incapable of providing protection against major floods.

Without additional protection future average annual flood damages may be expected to increase in proportion to the increase in economic activity in the flood plain. The trend of development would result in future growth of flood damages approximating 1.6 and 2.0 percent compounded annually without flood control or flood plain management in the Nisqually and Deschutes Basins, respectively.

Damage from a flood with a recurrence interval of 100 years would be $930,000 and $340,000, respectively, in Nisqually and Deschutes Basins. Structural flood control measures should be provided to the maximum extent that economics would permit and land areas should be managed to permit development commensurate with the flood protection provided. The projected flood damages are shown in Table 10-14.

TABLE 10-13. Major floods and estimated damages, Nisqually-Deschutes Basins

	NISQUALLY RIVER		
	Peak Discharge at McKenna (cfs)	Average Recurrence Interval (years)	Current Estimated Damages
29 Jan. 1965	25,700	20	$140,000
23 Dec. 1964	22,300	13	50,000
23 Nov. 1959	20,500	10	40,000
50-yr. flood	33,000 (est)	50	475,000
100-yr. flood	39,500 (est)	100	930,000
	DESCHUTES RIVER		
	Peak Discharge at Olympia (cfs)	Recurrence Interval (years)	Estimated Damages (1966 prices and conditions)
26 Jan. 1964	6,650	18	$130,000
13 Dec. 1955	6,080	12	90,000
26 Nov. 1962	5,000	5	30,000
50-yr. flood	7,900	50	240,000
100-yr. flood	8,800	100	340,000

TABLE 10-14. Projected flood damage reduction needs,[1] Nisqually-Deschutes Basins

Year	Total ($1000)	Net Needs[2] ($1000)
1966	57	57
1980	69	69
2000	110	110
2020	160	160

[1] Based on 1966 prices and conditions.

[2] Flood damages which would occur without additional measures.

Source: Appendix XII, Flood Control.

WATERSHED MANAGEMENT

General

Watershed management includes treatment measures for flood prevention, watershed protection and rehabilitation, and water management.

Present and Future Needs

There is a need for implementation of integrated programs and projects for flood water damage reduction and water management, with rehabilitation and protection of forest and watershed lands. The implementation of integrated programs and projects would meet the primary objectives and enhance water quality improvement, municipal and industrial water, fish and wildlife habitat, recreation and the Basins general environment.

The needs for watershed management are complex and two or more practices and measures may be required on the same area of land. Many measures and treatments become involved in integrated programs and projects. The watershed management needs for the Basins are tabulated in Table 10-15.

TABLE 10-15. Total watershed management needs, Nisqually-Deschutes Basins

Year	Flood Prevention[1] (acres)	Watershed Protection and Rehabilitation (acres)	Water Management Agriculture (acres)	Water Management Urban (acres)
1980	30,300	635,600	5,300	39,800
2000	30,300	635,600	9,000	39,800
2020	30,300	635,600	11,900	39,800

[1] Includes flooding on main streams.

Source: Appendix XIV, Watershed Management.

RECREATION

General

Mount Rainier National Park and Puget Sound are the most significant recreation features in the Basins. There also are numerous lakes and several rivers affording many recreation opportunities. The summer months are the most attractive for recreation. There are 17,600 acres of salt water and 8,083 acres of lakes and reservoirs, approximately 35 miles of the Nisqually River and 15 miles of the Deschutes River which are suitable for boating.

Present and Future Needs

In 1964 there were 42 publicly-administered outdoor recreation areas within the Basins, with 26 administered by the State. The existing supply of recreational developed land is inadequate to satisfy the 1960 boating, camping, and picnicking demands. Beaches are of sufficient quantity to satisfy swimming demands until 1980, but the supply of swimming pools is inadequate. Availability of natural waters is inadequate to satisfy water-based recreation demands. The future water-related demand expressed in recreation days is as shown in Table 10-16.

TABLE 10-16. Present and projected water-related recreation demand, Nisqually-Deschutes Basins (1000's recreation-days)

Year	Total	Net Needs[1]
1960	2,100	490
1980	4,200	2,590
2000	8,000	5,900
2020	14,900	12,800

[1] Cumulative needs above 1,610,000 recreation-days satisfied by facilities existing in 1960.

Source: Appendix X, Recreation.

In addition to indicated needs, urban parks, scenic routes, waterfront access, recreation rivers, special interest areas, interpretive facilities, open spaces, and beaches and trails for activities other than swimming and hiking are necessary to satisfy the recreation and environmental needs of the people.

The Nisqually Delta area located at the mouth of the Nisqually River has the potential for becoming one of the unique recreational areas in Puget Sound. It is the last large natural estuarine area in southern Puget Sound. The estuary is a major waterfowl resting area, hunting area, and potential scientific research area. Recreational use of the estuary would be compatible with all the above uses.

FISH AND WILDLIFE

General

The Nisqually River Basin presents considerable stream and streambed area suitable for anadromous fish use. These fish inhabit the main-stem Nisqually River for some 42 miles to the city of Tacoma dam at LaGrande. Accessible tributary streams offer approximately 80 additional miles of suitable spawning and rearing area.

The Deschutes River Basin, including the Capitol Lake rearing area, is one of the most important anadromous fish production areas of the southern Puget Sound Area. The Deschutes River

provides some 34 miles of main-stem spawning and rearing area, plus an additional 30 miles of accessible tributaries. Approximately 10 additional stream miles are available for spawning in the smaller independent sub-drainages. Anadromous fish spawning occurs principally in the lower 23 miles of the Deschutes River.

Anadromous fish inhabiting the Basins are chinook, coho, pink (Nisqually only), and chum salmon, and steelhead and cutthroat trout. An 11-month period of spawning occurs in both Basins requiring a firm minimum streamflow nearly year around.

The major limiting factor to fish production in the Nisqually River is streamflow regulation imposed by the Alder-LaGrande Dam power generation complex and the Centralia Power Canal diversion operation.

The principal limiting factor to fish production in the Deschutes River is low summer flow, which reduces the rearing capacity of the stream.

A prime waterfowl area in the Puget Sound is found in the Lower Nisqually River. This area is extremely important to survival of waterfowl populations utilizing the Puget Sound Area. The Department of Game which owns 647 acres is presently acquiring land in the delta for hunting, waterfowl habitat, and recreational development purposes.

Shellfish occur in large numbers along the Nisqually Flats area.

Present and Future Needs

Sport fishing demands for anadromous and resident fish would increase in both fresh and salt waters. The net accumulative fishing and hunting demand projected for the Basins are as shown in Table 10-17.

The average monthly flows necessary to maintain the present and projected levels of resident and anadromous fish are shown in Appendix XI, Fish and Wildlife.

The coordination of streamflow releases below Alder and LaGrande Dam and the Centralia power diversion would be established to allow sufficient water to be in the Nisqually River at all times for the passage, rearing and spawning of fish.

Capitol Lake is used as an artificial rearing area for salmon. The productiveness of the lake is dependent upon sufficient inflow at all times of the year, particularly during the summer months. A minimum inflow to the lake should be maintained.

Loss of forest and agricultural lands to intensive land use would reduce wildlife habitat and hunter recreation to some degree. Emphasis must be directed toward retention of those areas where the wildlife potential is the greatest. The greatest potential exists in the low elevation areas where all developed uses of land are generally in conflict with wildlife habitat.

The Nisqually Flats area is needed as a waterfowl nesting and resting area. It is also an area of ecologic and biotic significance, embracing many forms of plant and animal life in addition to traditional wildlife species. A development for wildlife in southern Puget Sound is needed to replace previous losses resulting from concentrated industrial development in basins to the north, as well as to meet projected demands for a greater human population and accelerating outdoor recreational desires.

TABLE 10-17. Fish and wildlife, sport and commercial needs, Nisqually-Deschutes Basins

	Unit	1965	1980		2000		2020	
		Total	Total	Net[1]	Total	Net[1]	Total	Net[1]
Sport Fishing								
Salmon	1000 User-Days	101	166	65	306	205	519	418
Game fish	1000 User-Days	484	809	325	1,271	787	2,034	1,550
Marine fish	1000 User-Days	10	14	4	18	8	24	14
Shellfish	1000 User-Days	19	26	7	35	16	46	27
Total		614	1,015	401	1,630	1,016	2,623	2,009
Hunting	1000 User-Days	72	139	67	226	154	278	206
Commercial Fishing	1000 Pounds	--	--	123	--	2,191	--	4,197

[1] Cumulative above 1965 activity.

Source: Appendix XI, Fish and Wildlife.

COMPREHENSIVE PLAN

BASIS OF PLANNING

Desires of Local People

At the public hearings held in Olympia on 28 October 1964, local interests expressed the needs for the retention of an irrigation water supply along with flood and debris control for the Deschutes River. The need for flood plain zoning, additional small boat moorages and facilities, expanded port facilities at Olympia, and a new deep water port located at Nisqually Flats was stressed. Others expressed needs for expanded recreational facilities and the preservation of the Area's streams for anadromous fish spawning.

Summary of Basin Needs

The needs of the Nisqually-Deschutes Basins for 1980, 2000, and 2020 are summarized in Table 10-18.

TABLE 10-18. Summary of needs, Nisqually-Deschutes Basins

Feature	Units	Cumulative Net Needs[1] 1980	2000	2020
M&I Water Supply	MGD	8.5	16.9	33.5
	(1000 Acre-Feet)	(9.6)	(18.8)	(37.4)
Irrigation	1000 Acre-Feet	5.2	17.1	36.0
Water Quality Control				
Waste Treatment	1000 Population Equivalents	166	315	561
Flow				
Nisqually River	cfs	30	50	60
Deschutes River	cfs	10	17	20
Navigation				
Commercial	1000 Short Tons	200	5,200	23,500
Pleasure Boats	Wet Moorages	650	1,430	2,180
Power[2]				
Flood Control	$1000 Damage Reduction	69	110	160
Watershed Management				
Flood Prevention	1000 Acres	30.3	30.3	30.3
Rehabilitation and Protection of Watersheds	1000 Acres	635.6	635.6	635.6
Water Management				
Agriculture	1000 Acres	5.3	9.0	11.9
Urban	1000 Acres	39.8	39.8	39.8
Recreation	1000 User-Days	2,590	5,900	12,800
Fish and Wildlife				
Sport				
Fishing	1000 User-Days	401	1,016	2,009
Hunting	1000 User-Days	67	154	206
Commercial Fishing	1000 Pounds	123	2,191	4,197

[1] See Water and Related Land Resource Needs section for derivation of net needs.

[2] Power needs were projected for the Puget Sound Area only.

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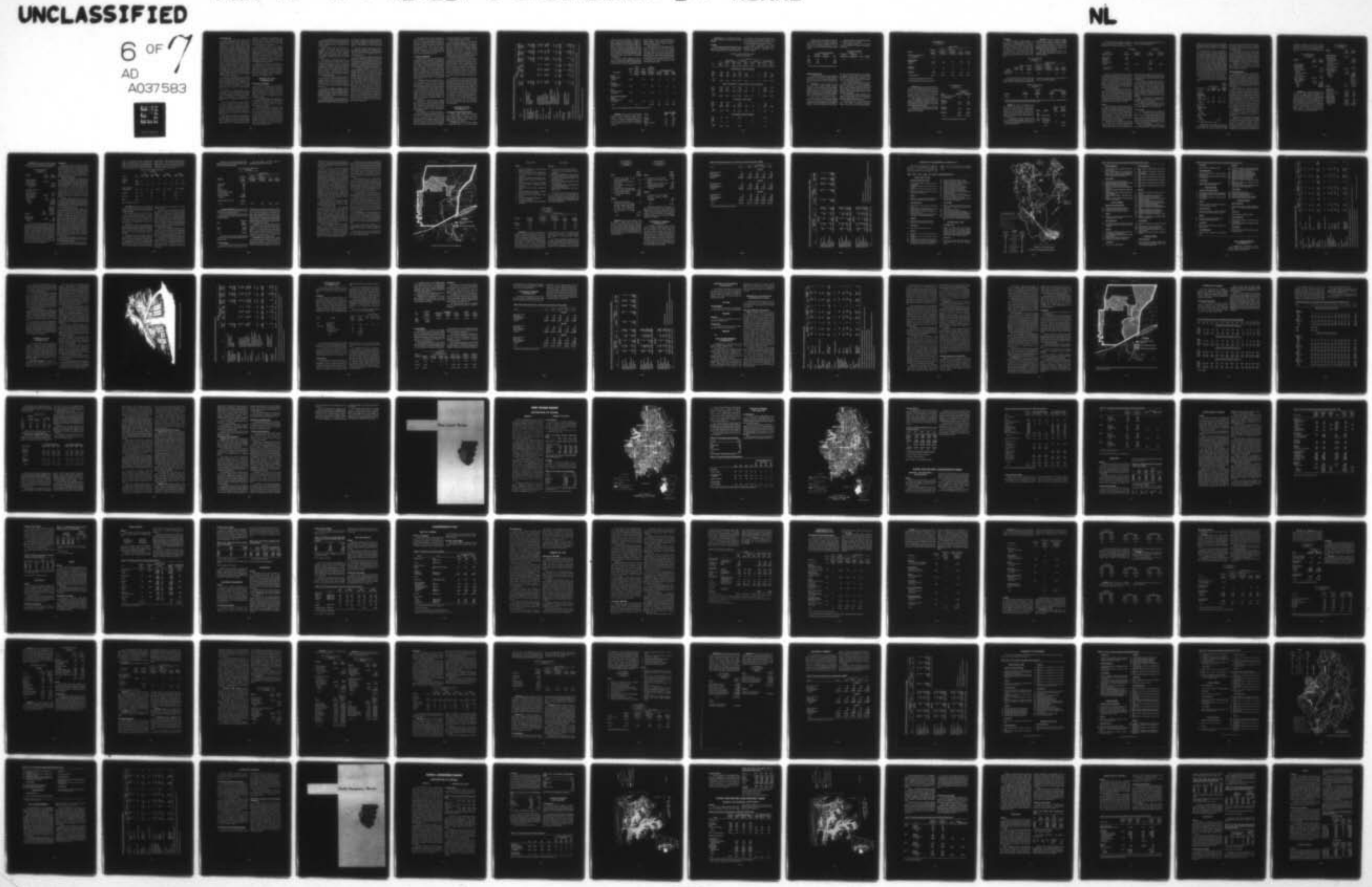
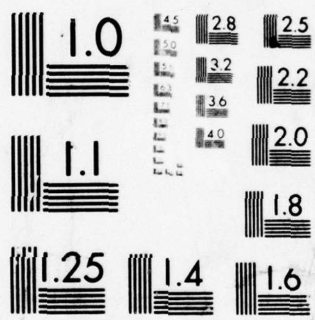




MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

General Planning

A wide range of alternative nonstorage and management opportunities were viewed in the Nisqually-Deschutes Basins. These included diversion structures, direct river pumping and treatment, desalinization, inter-basin water transfer, further ground water utilization, and improved water yields through various watershed management practices to satisfy water supply needs of municipalities and industry, irrigated farming, water quality preservation and enhancement, and fish use. Levees, channelization, diversion, flood plain evacuation, bank protection, and improved land use management practices were considered as possible means of meeting flood control and watershed management needs. Opportunities considered for satisfaction of water quality needs were sewage collection and treatment facilities and minimum flows available to assimilate residual wasteloadings. The water and related land resource was examined in terms of projected land use pattern C_2, (see Projected Land Use) with the land needs of navigation, power, recreation, and fish and wildlife considered within this context.

There are a few storage sites in the Basins streams which could provide opportunities for flood control; municipal, industrial and irrigation water supply; hydroelectric power, and an adequate streamflow for anadromous and resident fish. Low flow augmentation could be provided on the smaller tributaries by the construction of small headwater dams.

Construction of small offstream reservoir impoundments for use in conjunction with existing or new storage could provide additional water supply and flow augmentation. These offstream reservoirs provide the opportunity for development of pumped-storage for hydroelectric power generation also.

Alternative objectives were considered in developing the Comprehensive Plan. The objectives represented both ends of the spectrum of interests, i.e., economic efficiency and environmental quality as discussed in the Puget Sound Area section of this Appendix. The alternative elements considered in plan formulation are described under Alternative Elements.

The single-purpose Appendices, V through XIV, provided a wide array of solutions. Necessary adjustments were made to these solutions in the formulation of comprehensive plans for the Basins. These adjustments consisted of: the population projections as shown in Appendix V, Water-Related Land Resources, were increased for 1980 to more clearly reflect the impact of Evergreen State College which was authorized for construction after the base population projections were completed.

In developing the plan for the Nisqually-Deschutes Basins, conflicting uses for the Nisqually Delta arose which could not be readily resolved without further detailed study. Development of the Nisqually Delta as a port facility and water-oriented industrial location could conflict with the present and projected use of this resource as a natural biotic, recreational, and wildlife area. Since this is an area of high priority for both uses, alternative plans for use of the Nisqually Delta are presented.

Alternative A is a plan for a projected recreational-wildlife biotic research use of the delta. Alternative B provides for the utilization of a portion of the delta for a navigation port and related industrial development. A comparative discussion of Alternatives A and B is included in the section "Comparative Evaluation of Alternatives A and B" following the plan presentation of Alternative B.

SUMMARY OF PLAN
ALTERNATIVE A

Early Action, 1970-1980

The present municipal and industrial water supply needs for the greater Olympia area can be met from ground water. The present sources of supply are considered adequate, and enlargement of existing supply systems would meet the projected needs. Detailed studies should be undertaken during this time period to determine the capability of the local ground water supply.

The water supply system for the Olympia area and the small rural community water systems should be enlarged to provide the peak flow and fire protection delivery capability outlined in the State's water supply system standards.

Irrigation water supplies, including about 2,200 acres of new lands projected to be irrigated by 1980, can be met from both surface and ground water sources. In the Deschutes Basin, the irrigable lands are in an area with an excellent ground water resource and these lands can be expected to be irrigated from this source through private farm development. In the Nisqually River Basin, the irrigation water supply would be obtained from both surface and ground water sources. Irrigation systems would be constructed by the individual farmer.

To comply with Washington State water quality standards, waste treatment and sewer outfall facilities would be installed by the various industries for treating industrial wastes prior to discharge into the offshore waters.

Water treatment needs can be met with the construction of secondary waste facilities with adequate sanitary sewers at Paradise, Longmire, Olympia, and Lacey. Water quality surveillance stations would be established at three new locations in the Basins to regularly measure the water characteristics.

The Nisqually and Deschutes Rivers flow for the greater part of their length through a natural sanctuary where outdoor recreation is the primary use. Hence, wasteloading is expected to be light and minimum flows for other purposes such as fish would be sufficient to maintain a desirable water quality. A planned program of expanding waste treatment and sanitary sewers in all municipalities and small community systems would be necessary to keep pace with an expanding population.

To meet the rapidly increasing demand of boating enthusiasts, a small boat harbor with 230 wet moorages would be built with Federal funds. An additional 420 wet moorages would be provided by the private sector prior to 1980. Approximately half of these moorages could be built in the Olympia Harbor area.

To meet the navigational shipping needs, the terminal facilities at the Port of Olympia would have to be expanded to its maximum physical boundaries. Dredging the shipping channel to a depth of 40 feet would be necessary to handle the increasing deep draft of the modern fleets.

Flood plain regulations would be established to reduce existing and future flood damages on both the Nisqually and Deschutes River flood plains. One-hundred year flood protection would be provided for the 8,000-acre Nisqually flood plain below Alder Dam with the assignment of 55,000 acre-feet of storage in Alder Reservoir for flood control regulation.

Other water resource needs would be met by the progressive development and implementation of watershed management programs; particularly agricultural and urban water management and forest management measures.

The recreational plan includes land and facility developments interspersed throughout the Basins and along the shoreline of Puget Sound. With no additional upstream storage or similar upstream structural development, the Nisqually River, Mashel River, and tributary streams would be preserved in their present natural environment for use by future generations.

A minimum streamflow of 150 cfs for fish could be maintained in the 13-mile reach of the Nisqually River below the Centralia City Power diversion canal and above the powerhouse through agreement with the city of Tacoma and the city of Centralia. Streamflow records indicate that only a few times during the summer months has a flow this low occurred. The agreement would provide that this flow is maintained in the river. The streamflows for fish would be attained in the remaining Nisqually River due to the normal operation of Alder and LaGrande power facilities. Over 90 percent of the natural streamflow of the Deschutes River would be available for fish use. Other early action enhancement features for fish include spawning and rearing ponds and channels, an additional hatchery, stream channel clearance projects, acquisition and development of access to 7 lakes, and obtaining 50 miles of streambank greenbelt on the major river systems to insure public access to fishing areas.

The Nisqually Delta would be retained as a natural estuarine area. Access would be provided to the delta, and facilities developed to permit recreational use, wildfowl hunting, and biotic research. The Department of Game has presently acquired 627 acres for development of the area into such a multiple-purpose plan. Their on-going program includes the acquisition of 3,000 acres in the delta. The delta is being studied for inclusion into the Nation's system of natural estuarine areas.

Long-Range, 1980-2020

During this period, the municipal and domestic water supply systems would need to be enlarged and expanded to keep pace with the population expansion. Should it be found from the quantitative ground water studies to be conducted during the early action period that ground waters are not available in sufficient quantities to satisfy projected needs, utilization of surface waters of the Deschutes River and/or the Nisqually River could satisfy the additional municipal and industrial requirements. Upstream storage would be necessary for the development of the Deschutes River as a municipal and industrial source.

A continuing planning and implementation program for expansion of waste treatment and sanitary sewer facilities commensurate with a water quality surveillance program would be necessary to meet and maintain Washington State water quality standards.

Irrigation expansion would continue with an additional 13,000 acres of new lands projected to be irrigated. These lands are expected to be in scattered parcels throughout the Basins. The irrigation water supplies are expected to be obtained primarily from ground water. Irrigation development would be by private investment.

Additional wet moorages would be provided with construction of small boat harbors at Budd Inlet, Nisqually Delta, and Henderson Inlet. With these developments, an additional 3,610 wet moorages would be provided by 2020. These facilities would include moorages to handle a deficit need in the Puyallup Basin.

The Hawks Prairie area would be developed as a water-oriented industrial area. Minimum port facilities would be developed adjacent to the industrial area and a minimum amount of waterfront land would be taken for the actual port development. The development plan to be provided for the area should become a component part of the navigation plan for Puget Sound. This plan should include a compilation of related industrial and recreational uses with minimum environmental quality impacts.

Flood control storage of 15,000 acre-feet would be provided by development of a dam and reservoir at the Shellrock Ridge site on the Deschutes River by year 2020. This would provide 100-year protection to the long, narrow 2,700-acre Deschutes River flood plain. The use of levees to provide protection in this narrow flood plain are not economical and would be undesirable from an aesthetic, fish, and recreational standpoint. The flood plain management program would be continued.

Prior to the year 2020, land treatment facilities and small watershed multiple-purpose projects would be provided at specified locations along the Deschutes and Nisqually Rivers, Henderson and Budd Inlets, and tributary streams to the Nisqually River. These projects would provide adequate water management, small watershed flood protection, and soil stabilization for approximately 636,000 acres. Watershed management programs which offer technical assistance and financial participation in local land and water-related projects and programs would be continued.

An additional 5,793 acres of land with appropriate facilities would be acquired and developed for recreational use. The fish and wildlife plan emphasizes additional spawning and rearing areas, channel clearance, educational programs, and acquisition of key wildlife ecological and hunting areas. Table 10-19 shows all elements of Alternative A and the attendant costs. The output of the programs are complementary to the listed project facilities. The early action plan for Alternative A includes programs amounting to \$41,269,000 and projects costing \$35,820,000 for a total investment of \$77,089,000. Program and project investment costs for the 1980-2000 period amount to \$120,703,000 and for the 2000-2020 period \$112,560,000 for a total 50-year investment of \$310,352,000.

FEATURES OF PLAN ALTERNATIVE A

Municipal and Industrial Water Supply

Available studies indicate that the Basins ground water supplies are adequate to meet the future demands. However, detailed ground water studies should be undertaken prior to 1980 to better define the ground water capability.

1970-1980—The waters of McCallister Springs are considered adequate to meet the projected

TABLE 10-19. Comprehensive Plan, Alternative A, Nisqually-Deschutes Basins

Feature	Item	1970-1980 Investment[1] Costs ($1000)	1970-1980 Average Annual Costs ($1000)	1970-1980 Average Annual Benefits Gross ($1000)	1970-1980 Average Annual Benefits Net ($1000)	1980-2000 Investment Costs ($1000)	2000-2020 Investment Costs ($1000)	1970-2020 Investment Costs ($1000)
Management Programs								
Water Quality Control	Monitoring, Evaluation and Control Programs	350				240	286	876
Flood Control	Flood Plain Management	82				114	114	310
Watershed Management	Programs	40,710				68,131	34,506	143,347
Fish & Wildlife	Programs	127				478	470	1,075
Total Programs		$41,269				$ 68,963	$ 35,376	$145,608
Nonstorage Projects								
M&I Water Supply	Ground Water Use	1,290	168	168[3]	0	435	1,167	2,892
	Surface Water Use	0	0	0	0	0	0	0
Irrigation	Ground Water Use	273	32	32[3]	0	545	850	1,668
	Surface Water Use	27	3	3[3]	0	135	230	392
Water Quality Control	Waste Treatment and Collection Facilities	5,375	289	289[3]	0	6,760	10,200	22,335
Navigation	Channel Improvements	1,853	92	138	46	3,713	0	5,566
	Small Boat Harbors	(459)[2]	(29)[2]	(43)[2]	(14)	(4,387)[2]	(2,435)[2]	(7,281)[2]
Flood Control	Levees	0	0	0	0	0	0	0
Watershed Management	Floodwater Damage Reduction Water Management, Protection and Rehabilitation	0	0	0	0	4,340	100	4,440
Recreation	Land Acquisition, Access and Facilities	21,951	1,697	2,590	893	30,200	53,700	105,851
Fish & Wildlife	Production Enhancement Facilities, Access and Acquisition	5,051	494	1,456	962	5,612	7,437	18,100
Total Nonstorage		$35,820	$2,775	$4,676	$1,901	$ 51,740	$ 73,684	$161,244
Storage Projects								
Flood Control	Alder Dam and Reservoir	0	--	39	39	0	0	0
	Shellrock Ridge Dam and Reservoir	0	0	0	0	0	3,500	3,500
Fish and Wildlife	Alder Dam and Reservoir	0	0	43	43	0	0	0
Total Storage		$ 0	$ 0	$ 82	$ 82	$ 0	$ 3,500	$ 3,500
Total Programs and Projects		$77,089	$2,775	$4,758	$1,983	$120,703	$112,560	$310,352

1 Includes cumulative annual program costs for the period for management features and capital costs for nonstorage and storage projects.

2 General navigation facilities costs and benefits for public small boat harbors only. Total pleasure boat facilities costs and benefits included with Recreation.

3 Average annual benefits assumed equal to average annual costs.

maximum monthly requirements of Olympia. A booster pump would be necessary to increase the delivery capability of the system from 16 mgd to 21 mgd. Should additional water supplies in excess of 21 mgd be needed prior to year 2020, an additional pipeline to Olympia from McCallister Springs would be required. Should the demand increase to over 30 mgd, the capability of McCallister Springs pool, wells into the shallow ground water aquifers which supply McCallister Springs could provide the additional water supplies.

The source of water supply for the city of Lacey from the Woodland Creek drainage through the Huntamer well system is considered adequate for the year 2020. There is need to enlarge and update the present system to meet the State's municipal water supply standards; further enlargement would be necessary during each of the study time periods to meet the projected demands.

The ground water sources around the Deschutes River which supply the city of Tumwater are adequate to meet that city's year 2020 demand. Tumwater's supply system would require updating and enlargement to meet projected demands. The Olympia Brewery would continue obtaining supplies from its present source. Ground water sources are considered adequate throughout the Basins to meet the demands of the small rural systems and the individual domestic systems.

Development	Needed by Year	1980 Average Daily Water Use (mgd)	Total System Capability (mgd)	Supply, Transmission & Treatment Investment ($1000)	Average Annual Costs Investment ($1000)	O&M[1] ($1000)	Total ($1000)
Olympia							
Increase delivery capability	1970		35.0	840	39	61	100
Tumwater							
Local ground water development	1970		4.5	210	10	13	23
Lacey							
Local ground water development	1970		4.5	210	10	13	23
Small and Rural Community Systems							
Local ground water development	1970		6.9	30	1	21	22
Total		16.1		$1,290	$60	$108	$168

[1] Total incremental increase above present. Includes pumping and treatment costs.

1980-2020–During this period the municipal, industrial, and rural community systems must be enlarged to keep pace with future demands. Surface water may be required to supplement ground water sources. The schedule for updating and enlarging the municipal supply systems is shown in the following tabulation:

Facility	Investment ($1000) 2000	2020
Olympia	--	660
Tumwater	210	240
Lacey	210	240
Small rural systems	15	27
Total	435	1,167

Implementation of this schedule would satisfy the Basins municipal and domestic water supply demands.

Irrigation

Future irrigation development would be located primarily in the Nisqually Basin. Potentially irrigable lands are located in scattered small tracts which are not conducive to project-type development. Consequently, all irrigation development is expected to be by the individual farmer with the required water supply coming largely from ground water sources.

New irrigation requirements for the Basins including location, acreage, water supply source, diversions, and depletions is summarized in the following tabulation:

Summary of Irrigation Water Requirements
Nisqually-Deschutes Basins

				Diversions					
		Supply Source		Annual		Peak		Net Depletions	
Year	New Irrigation (acres)	Ground Water (acres)	Surface Water (acres)	Ground Water (acre-feet)	Surface Water (acre-feet)	Ground Water (cfs)	Surface Water (cfs)	Ground Water (acre-feet)	Surface Water (acre-feet)
SMITH PRAIRIE–NISQUALLY RIVER									
1980	500	500	--	1,200	--	7	--	800	--
2000	1,500	500	1,000	1,200	2,400	7	15	800	1,500
2020	1,000	500	500	1,200	1,200	7	7	800	800
Total New	3,000	1,500	1,500	3,600	3,600	21	24	1,600	2,300
McKENNA-KAPOWSIN–TANAWAX, MUCK & LACAMAS CREEKS									
1980	1,000	800	200	1,900	500	12	3	1,200	300
2000	3,000	3,000	--	7,100	--	44	--	4,600	--
2020	6,000	5,000	1,000	12,000	2,400	74	15	7,800	1,500
Total New	10,000	8,800	1,200	21,000	2,900	130	18	13,600	1,800
EATONVILLE–OHOP CREEK									
1980	100	100	--	240	--	1	--	150	--
2000	500	500	--	1,200	--	7	--	800	--
2020	1,000	800	200	1,900	500	12	3	1,200	300
Total New	1,600	1,400	200	3,300	500	20	3	2,200	300
WEIR PRAIRIE–DESCHUTES BASIN									
1980	600	600	--	1,400	--	9	--	900	--
2000	--	--	--	--	--	--	--	--	--
2020	--	--	--	--	--	--	--	--	--
Total New	600	600	--	1,400	--	9	--	900	--

Available ground water supplies are sufficient to meet irrigation needs, and natural streamflow in the tributary streams can adequately provide the surface water requirements indicated in the above tabulation, without jeopardizing streamflows needed for fish.

Irrigation development as projected would meet the irrigation objectives for the Basins.

Total estimated investment costs for private irrigation development in the Basins are expected to be as follows:

	Investment Costs ($1000)			Average Annual ($1000) Costs			
Year	Nisqually River Basin	Deschutes River Basin	Total	Interest & Amortization	Operation & Maintenance	Total	Benefits[1]
1980	218	82	300	10	25	35	35
2000	680	--	680				
2020	1,080	--	1,080				

[1] Private investment benefits assumed to be equal to costs.

Water Quality Control

A substantial investment in waste treatment and sanitary sewers would be necessary during the next 50 years to keep abreast of the needs of an expanding population and limited industrial expansion.

1970-1980–The towns of Paradise and Longmire would need to install secondary treatment facilities to satisfy Washington State Water Quality Standards. The city of Olympia should provide adequate treatment of wastes, disinfection facilities and an adequate outfall into Budd Inlet. Additional sewers are being provided for Lacey and these sewers will be connected to the Olympia treatment plant.

Future growth of population and industry would be concentrated in the Olympia-Tumwater vicinity. The wastes generated by this projected development should be handled through expansion of Olympia's facility with discharge to marine waters. The smaller towns located further up the Nisqually and Deschutes Rivers; Rainier, Yelm, Roy, and Eatonville on the Mashel River are expected to retain more of a rural character and therefore can continue to rely on individual disposal facilities.

A water quality surveillance program would be continued to insure that the harbor and offshore waters are maintained to the minimum Federal and State standards. Additional stations would be established in Henderson Inlet, Budd Inlet, and Alder Reservoir. The annual surveillance program costs are estimated to be $4,400.

The minimum water quality streamflows of 30 cfs and 10 cfs required by 1980 in the Nisqually and Deschutes Rivers, respectively, can be maintained with the minimum fish flow requirements.

The investment costs of the treatment and sewer outfall facilities and projected surveillance program costs are shown in the following tabulation:

Water Quality Control
1970-1980

Feature	Investment Costs ($1000)	Average Annual Costs: Interest & Amortization ($1000)	Average Annual Costs: Operation & Maintenance ($1000)	Average Annual Costs: Total ($1000)	Benefits[2] ($1000)
Monitoring, Evaluation and Control Program[1]	350				
Municipal Waste					
Treatment	1,850	95	1.7	97	97
Sewers	1,850	87	1.7	88	88
Industrial					
Treatment	775	40	0.7	41	41
Recreation	900	62	0.9	63	63
Total Investment	$5,725	$284	$5.0	$289	$289

[1] Cumulative annual program costs for the period.

[2] Benefits are assumed to be at least equal to the cost.

1980-2020–During these periods expansion by industry, new developments and growth of urban and recreation areas correspondingly would require that new sewer interception systems be installed and treatment facilities enlarged and/or constructed. Summarized below are estimated investment costs for water quality control by sectors for each period.

Local comprehensive sewage drainage basin plans and implementation programs are needed to schedule the construction of facilities and to define the surveillance programs necessary to comply with water quality needs of the Basins.

Construction of these facilities and continuance of the surveillance program would meet the water quality needs of the Basins.

Water Quality Control
1980-2020

Feature	*Investment Costs* ($1000) 1980-2000	*Investment Costs* ($1000) 2000-2020
Monitoring, Evaluation and Control Program[1]	240	286
Municipal		
Treatment	1,550	2,500
Sewers	1,550	2,500
Industrial		
Treatment	1,960	3,000
Recreation	1,700	2,200
Total	$7,000	$10,486

[1] Cumulative annual program costs for the period.

Navigation

Although significant tonnage measures are projected for the Nisqually-Deschutes Basins, the total Olympia port tonnage volume is not expected to significantly expand due to lack of adequate physical land space, the shallow harbor and small turning basin. Major tonnage increases were projected assuming development of the Nisqually Delta. Under Alternative A major portions of increase in the projected tonnage volume would be handled at other ports.

1970-1980–To meet the projected shipping needs the Port of Olympia is expected to expand the water-oriented terminal and industrial facilities from their present development of 134 acres to the maximum physical boundaries of 540 acres. The harbor channel would be dredged to a depth of 40 feet to handle the larger draft vessels.

The costs and associated benefits for the projected channel improvements are shown in the following tabulation:

Navigation Improvements
1970-1980

				Average Annual Costs			
Channel	Length (miles)	Channel Depth (feet)	Investment Costs ($1000)	Interest & Amortization ($1000)	Operation & Maintenance ($1000)	Total ($1000)	Benefits ($1000)
West Waterway Budd Inlet	3.8	40	$1,853	$87	$5	$92	$138

The increased demand for small boat moorages would necessitate construction of a new small boat harbor by 1980 containing 230 wet moorages. The investment cost and annual costs and benefits are shown in the following tabulation:

Small Boat Harbor Projects
1970-1980

			Average Annual[1]	
Location	Wet Moorages	Investment Costs ($1000)	Costs ($1000)	Benefits ($1000)
Olympia	230	459.2	29.4	42.6

[1] General navigation facilities costs and benefits only based on 50-year economic life amortized at a 4-5/8% interest rate. Total pleasure boat facilities costs and benefits included with Recreation.

1980-2020–To meet the year 2000 port and water-oriented industrial land and terminal facility needs, approximately 3,000 acres of land could be acquired by the Port District on Hawks Prairie. Minimal waterfront lands would be acquired for the actual port development while a large back-up area would be developed for terminal facilities and water-oriented industry.

To accommodate projected vessel drafts the Port of Olympia harbor channels would have to be deepened. The channel improvement costs are shown in the following tabulation:

Period	Channel	Channel Depth (feet)	Investment Costs ($1000)
1980-2000	West Waterway	46	1,360
1980-2000	East Waterway (Government Waterway)	46	2,353
	Total		$3,713

The salt water small boat harbor developments would continue with the addition of 2,180 wet moorages by year 2000 and an additional 1,210 wet moorages during the period 2000-2020. These are shown in the following tabulation:

	1980-2000		2000-2020	
Small Boat Harbor Locations	Wet Moorages	Investment ($1000)	Wet Moorages	Investment ($1000)
Nisqually Flats	1,180			
Budd Inlet I	1,000			
Budd Inlet II			680	
Henderson Inlet			530	
Subtotal	2,180	$4,387	1,210	$2,435
Cumulative Total above 1970	2,410		3,620	

Because of the high construction costs, the salt water small boat harbor projects for 2000 and 2020 would be built by public agencies with Federal aid. It is assumed that private interests would provide the 420 wet moorages needed for the year 2020. The number of moorages shown exceeds Nisqually-Deschutes Basins needs. This overage would partially relieve the projected shortages due to inadequate site locations in the Puyallup Basin.

The small boat harbor land and facilities investment costs and associated benefits are contained as part of the recreation plan. Obtaining the land and water areas and constructing the small boat harbor facilities carried in the recreation plan would satisfy the salt water small boat harbor needs for the Basin. Developing the harbor facilities recommended above would satisfy the navigation needs of the Basin.

Power

The existing power generation facilities located in the Basin are expected to continue their operation with some minor operational adjustments. To provide minimum low flows for fish in the Nisqually River past the city of Centralia diversion would require some modification of operation during the summer months in order that a minimum of 150 cfs is left in the river below the point of diversion. This is discussed further in Fish and Wildlife.

The Alder Dam and reservoir provide, through their normal course of operation, approximately 100-year flood protection to the 8,000-acre flood plain below Alder Dam. To obtain reliable protection, a formal agreement should be made between the city of Tacoma, owners of Alder Dam, and the responsible governmental agencies. This is discussed further under Flood Control.

Thermal-nuclear generating plants would be required at a number of locations in the Puget Sound Area during the next 50 years to meet the future energy requirements. Before determination of plant locations, further site and environmental studies would be necessary. Sites for nuclear power plants may be investigated in the Basins at some future time. Further discussion on nuclear power generation is included in the Puget Sound Area section of this Appendix.

There is some potential for pumped-storage development in the Basins, but further study is needed to determine its true potential.

The Basins power demands are presently met through a regional power interchange and future needs would continue to be met from this source.

Flood Control

Flood plain regulations should be adopted by the county and State to limit or restrict urban development on the Basins flood plains consistent with the level of existing flood protection. The regulations would protect against channel encroachment, prevent or minimize material losses, and reduce the cost of relief and rescue occasioned by the unwise occupancy of such flood areas.

After an initial investment of $82,000 for flood plain information studies, zoning, and regulation

implementation costs, the annual cost of a flood plain management program is estimated to be $3,200 for the Nisqually Basin and $2,500 for the Deschutes Basin.

An agreement with the city of Tacoma to provide 55,000 acre-feet of storage in Alder Reservoir would provide 100-year protection to 8,000 acres of the 9,000-acre Nisqually flood plain below Alder Dam during the period November 1 through March 1. The city of Tacoma in the past has provided this protection as a result of its power releases in all but a few years since initial operation of Alder Reservoir. The agreement, however, would formally establish this protection. Benefits resulting from the storage protection would amount to $39,000 annually for the flood plain and $33,000 for reduction of damage to fish spawning areas. Future power losses, if any, resulting from including flood control storage as a project purpose would require evaluation by the owner and reimbursement as part of the agreement.

The flood control features, costs and sequence of development are shown in the following tabulation:

Flood Control Element	Investment Costs ($1000) 1980	2000	2020	Average Annual Cost ($1000) 1980
Flood Plain Management				
Nisqually River Basin	43	64[1]	64[1]	3.2
Deschutes River Basin	39	50[1]	50[1]	2.5
Subtotal	82	114	114	5.7
Flood Control Storage				
Storage at Alder Dam 55,000 acre-feet	0	0	0	
Shellrock Ridge Dam 15,000 acre-feet			3,500	

[1] Cumulative program cost for the period.

Establishment of flood plain regulation along the Deschutes River would partially satisfy flood control needs here until year 2000. A 15,000 acre-foot reservoir at the Shellrock Ridge site, which would provide 100-year protection to the 2,700-acre flood plain, is projected for construction during the period 2000 to 2020.

Should localized areas, presently undeveloped, require additional protection prior to the year 2000, local levees or channelization could be constructed to provide sufficient protection. Flood plain regulations would be established for the 1,000-acre flood plain near the boundary of Mount Rainier National Park on the Nisqually River to guide any future development.

Establishment and maintenance of the flood plain regulations and incorporation of the flood control facilities as discussed would satisfy flood control objectives for the Basins.

Watershed Management

The development of resources in the Nisqually-Deschutes Basins would require a coordinated multi-agency watershed management program designed to reduce ground water damage, rehabilitate the forest stands and protect watershed areas, and provide water management for a variety of purposes on rural and urban lands. These developments would be guided by requirements for environmental quality and by local land use zoning.

Many structural and nonstructural measures combine to form the array of practices required to accomplish these purposes. Representative measures are described in detail in Appendix XIV, Watershed Management. While the acreage requiring treatment remains fairly constant by time periods, the intensity of treatment application, and the composition of the combined measures, varies with the inherent capability of the land as well as with the kind and intensity of use. Benefits from proper application of these measures are increased production, protection from watershed deterioration, forest fire protection and enhancement of many environmental qualities.

1970-1980–The early action program would consist entirely of land treatment measures to accomplish specific objectives for conservation and development.

Federal and State land administrative agencies are responsible for the installation of applicable measures on land assigned to their management, while the initiative of individual property owners is required for installation of practices on lands in private ownership. Various Federal and State agencies have programs of tehnical and financial assistance for individuals, local organizations, and subdivisions of

government. Non-Federal costs include on-going programs which would be redirected and accelerated according to need. The program measures for the early action plan are shown in the following tabulation:

Watershed Management
1970-1980

Program	Area (acres)	Costs ($1000)
Technical assistance and management	595,788	
Federal, regular		5,854
Federal, accelerated		0
Subtotal		$ 5,854
Installation of practices (non–Federal)		
State and corporate		11,057
Land treatment	447,855	4,756
Water management		
Agricultural	5,331	1,130
Urban	13,269	17,913
Subtotal		$34,856
Total		$40,710

1980-2000–Due to population expansion and the need for a higher degree of management and protection, the program would be accelerated in the years after 1980 by installation of multiple-purpose watershed projects to reduce floodwater and sediment damages, improve water management and provide rehabilitation and protection to the watershed lands. After 1980 some water management, protection and rehabilitation and small watershed projects would be required. The program costs, project locations and structural measures installation costs are shown in the following tabulation:

Watershed Management
1980-2000

Program	Area (acres)	Costs ($1000)
Technical assistance and management	595,788	
Federal, regular		10,524
Federal, accelerated		802
Subtotal		$11,326
Installation of practices (non-Federal)		
State and corporate		14,743
Land treatment	447,855	6,341
Water management		
Agricultural	3,554	933
Urban	25,769	34,788
Subtotal		$56,805
Total		$68,131

Projects	Area (acres)	Structural Measures Installation Costs ($1000)
Nisqually Basin:		
Muck Creek	70,532	780
Horn-Tanawax Creek	33,806	650
Ohop Creek	27,604	300
Nisqually River	268,644	1,200
Deschutes Basin:		
Deschutes River	96,048	550
Henderson Inlet	62,054	700
West Budd Inlet	22,256	160
Total	581,394	$ 4,340

2000-2020—The projects and programs needed to meet the watershed management needs during this time period are shown in the following tabulation:

Watershed Management 2000-2020

Program	Area (acres)	Costs ($1000)
Technical assistance and management	595,788	
Federal, regular		10,807
Federal, accelerated		115
Subtotal		$10,922
Installation of practices (non-Federal)		
State and corporate		14,743
Land treatment	447,855	6,341
Water management		
Agricultural	4,181	1,328
Urban	631	1,172
Subtotal		$23,584
Total		$34,506

Projects[1]	Area (acres)	Structural Measures Installation Costs ($1000)
Nisqually Basin:		
Mashel River	54,200	100
Total		$ 100

There is a continuing investment needed, both public and private, to insure protection of the water and related land within the Basin under projected development. This investment would be made in the form of financial assistance, technical assistance, research, education and information, and general management of the resource by the public and private agencies. Private investment would be contained in the foregoing programs and in the final accomplishment of the specific project measures. Private costs include continuation, redirection of on-going costs plus costs induced by new development.

Recreation

The nearly 60 miles of salt water shoreline containing numerous covers and bays, many miles of streams and rivers, lakes, and the Rainier National Park can all fully support an expansion of recreational development. Additional campgrounds and picnic areas are planned on National Forest land in the Basins eastern part and on State lands as well as lands within the National Park.

Through the development of suitable areas on existing publicly-administered lands, approximately half of the picnicking requirements would be satisfied on undeveloped lands, an additional 2,670 acres of campground and 970 acres of picnic area would need to be developed to satisfy 2020 demands. This acreage does not include the necessary buffer zones on the periphery of developed recreation lands. Approximately 60 percent of the picnicking and camping needs by the year 2020 can be satisfied through the development of suitable areas on existing public lands.

The Basins have significant types and amount of year-round recreation areas. The primary needs are of acquiring lands and public access, and developing recreational facilities for public usage. However, some areas in the Basins need to be retained in their natural state for use by future generations.

The broad recreation goal is to promote well-planned development and protection of the existing resources and to provide an opportunity for the satisfaction of present and future outdoor recreation demands of the population. Based on Federal ownership of land, plans and programs of recreation suppliers, and expected population concentrations as well as outdoor recreation needs, the assumption is made that the Federal agencies would provide 20 percent of the future required water-related opportunities, while the State, county and local agencies, and the private sector would supply 25, 35, and 20 percent, respectively. Recreational opportunities that could economically be provided by commercial interests include winter sports facilities, camp and picnic areas, swimming facilities, resorts, and fishing and hunting areas.

The recreation development would be coordinated with the State of Washington Recreation Plan during all stages of development.

To satisfy part of the recreational demands the lands and water areas which must be acquired are

shown in the tabulation below. A similar land acreage, in low-density use, would be required to act as buffer around the developed recreational areas. In addition to new development, some existing facilities would be rehabilitated and expanded to accommodate projected use. Recreational developments would include interior roads, sanitation facilities, water supply, parking, and other use facilities. Recreation areas which should be given firm consideration for development are shown on Figure 10-4.

Recreation Land and Water Requirements
1960-2020

		1960		1980		2000		2020	
Activity	Unit	Land	Water	Land	Water	Land	Water	Land	Water
Swimming									
Beaches	Acres	0	0	2	1	12	4	67	12
Pools	1000 Sq. Ft.	23.9	11.4	72.9	36.4	167.9	83.4	327.9	168.4
Boating Sailing and Water Skiing	Acres	26	0	86	23,700	201	80,700	426	190,700
Camping	Acres	273	--	643	--	1,443	--	2,943	--
Picnicking	Acres	117	--	287	--	587	--	1,082	--
Hiking	Miles	0	--	50	--	180	--	410	--

Source: Appendix X, Recreation.

1970-1980—During this period an additional 652 acres would be acquired and in some areas, camping, picnicking and other recreation facilities would be developed.

Rivers which may qualify for study for inclusion into the State system of recreation rivers include the Nisqually River from Puget Sound to the powerhouse below Alder Lake. The retention of the Nisqually River in a near-natural state could be tied in with a designation of Nisqually Flats as an outstanding natural area.

Approximately 20 miles of the Nisqually River shoreline plus several lakes are within the Fort Lewis Military Reservation. Public recreation use is allowed at some areas in the reservation, and it has been assumed in the plan that this policy would be continued.

A network of scenic roads would be designated and established by the State to provide travel links between recreation attractions and to enhance sightseeing opportunities. Scenic-access easements would be established along sections of the Nisqually and Deschutes Rivers, tributary streams, and along the salt water shoreline. Hiking trails would be developed within the easements and convenient road access provided to them.

As there are not enough natural waters within the Basins to satisfy the water-based recreation demand after 1990, additional use must be made of facilities in the Basins where adequate potential exists. Abundant marine waters and fresh water lakes which are seldom visitedare available in the adjacent West Sound Basins. Access to these lakes is convenient for the people residing in the greater Olympia area. The facilities in the West Sound Basins have been sized to meet this projected demand overage of the Nisqually-Deschutes Basins.

There are four outstanding natural areas to be retained for the use and enjoyment of present as well as future generations. These areas are: (1) Deschutes River near Tumwater—100 acres, (2) Julia Falls scenic area—32 acres, (3) Sawtooth Ridge scenic area—1,213 acres, and (4) the Nisqually River delta—3,000 acres.

In addition to its recreational potential, the Nisqually River delta is an important waterfowl area. This is one of the few remaining unspoiled areas in coastal Puget Sound, and would be retained for future generations as a recreational, wildfowl, and hunting area.

Investments for recreation facilities other than those discussed previously are tabulated below for the various water-related improvements.

The 1980 facilities are sized to meet the 490,000 unmet recreation days of 1960.

Outdoor Recreation Improvements
1970-1980

Feature	Investment Costs ($1000)	Average Annual Costs: Interest & Amortization ($1000)	Operation & Maintenance ($1000)	Total ($1000)	Benefits ($1000)
Campgrounds	9,002				
Picnic areas	889				
Trails	300				
Beaches	24				
Swimming pools	911				
Boating facilities including small boat harbors	2,497				
Planning and design	3,406				
Subtotal	$17,029				
Land Acquisition Inc. buffer	4,922				
Total	$21,951	$1,025	$672	$1,697	$2,590

Long-Range 1980-2020–During this period the *additional land and water areas necessary to meet* recreational needs would be acquired.

The total investment costs for the water related recreational lands and facilities are shown in the following tabulation:

Year	Investment Costs ($1000)
2000	30,200
2020	53,700
Total	$83,900

Acquiring the land and developing the facilities contained in the recreational plan would satisfy the recreation needs.

Fish and Wildlife

The Nisqually-Deschutes Basins offer numerous opportunities for projects and programs that, if implemented, would maintain and increase the wild*life, fish and shellfish production*. The Basins contain a very important anadromous fish inhabiting the Basins–river systems include chinook, coho, pink and chum salmon, steelhead and searun cutthroat trout. The distribution of anadromous fish and game habitat areas is presented in Appendix XI, Fish and Wildlife. Shellfish including crabs, oysters; and hard-shell clams are found in Basin marine waters.

Development of the fish and wildlife resource would follow a three-step planned procedure as outlined in the Puget Sound Area. Initial action would be to clear, clean-up and develop natural habitat to achieve maximum production. This would be followed by hatcheries, artificial spawning and rearing areas and game farms to further increase production of both fish and wildlife species.

1970-1980–Fish and wildlife facilities included in the early action plan would provide for: additional spawning and rearing areas, channel clearance and streambed improvement, acquisition and development of access areas, development of waterfowl and

upland bird habitat, and acquisition and development of 50 miles of streambank greenbelts and associated access along the Nisqually and Deschutes Rivers and tributary streams.

Prior to 1980, an operational agreement between the city of Tacoma, the city of Centralia, and Departments of Fisheries and Game should be made whereby a minimum allowable streamflow of 150 cfs is maintained in the 13-mile stretch of the Nisqually River downstream from the Centralia power diversion and upstream from the powerhouse. The benefits to fish resulting from this minimum firm flow would amount to $9,700 annually. Above the diversion and below the powerhouse, there is adequate streamflow to provide optimum spawning and rearing conditions for fish. If an agreement cannot be obtained to provide the minimum flow, then a proposal could be made to the Federal Power Commission requesting assistance through their regulatory powers of licensing of power facilities. The Centralia diversion and power facilities have not been licensed by the FPC, and their operation could be altered for multiple-purpose uses.

With the addition of firm flood control storage in Alder Reservoir, benefits amounting to nearly $33,000 annually would accrue to fish from reduction of in-stream habitat damage.

In the Deschutes River, a 50 cfs minimum streamflow prime water right has been granted for fish. The requested streamflow for fish above the existing fish water right streamflow cannot be attained without upstream storage. Inclusion of storage at the Shellrock Ridge Dam and reservoir site to provide the additional streamflow along with other multiple purposes was investigated. The additional streamflow for fish from storage cannot be economically justified until after year 2000.

The mean monthly low summer flow averages about 100 cfs at Olympia and 45 cfs at Rainier, which is located at about river mile 20.0. The principal spawning area is in the lower 23 miles of the river. With the inclusion of hatcheries and additional rearing area in the plan, the projected production levels of anadromous fish would be attained without upstream storage until approximately year 2000.

Capitol Lake, near the mouth of the Deschutes River, is an important semi-artificial rearing impoundment for salmon. Adequate stream inflow is necessary to retain the rearing characteristics of the lake. Plans include an expanded chinook salmon rearing program which would more than double production of this specie. Should additional consumptive diversion be allowed upstream, then storage would be required to retain or accomplish the desired fish objective for Capitol Lake.

The minimum flows in the small tributary streams are generally adequate during the late summer months for meeting fish needs. Should large diversion be placed upon these streams, small upstream impoundments might be required to provide adequate fish flows. These diversions would not occur in the immediate future, and impoundments have not been costed and included as part of the plan.

The Nisqually Flats delta would be retained as a natural multiple-purpose recreational-wildlife area. The Department of Game presently owns 627 acres of its proposed 3,000-acre area as shown on Figure 10-5. The present plans of the department is to retain as much of the natural characteristics of the area as possible while developing it for the multiple-purpose uses of recreation, waterfowl nesting and resting, hunting, and a biotic research area. The peripheral area acquired at Nisqually Flats would be planted into grain for waterfowl to optimize the potential of the area for waterfowl.

Nonconsumptive use of the Nisqually Delta in a near-natural state would far exceed the hunting use and the extensive clam digging and fishing would extend the use to near year-round for recreational purposes. Further discussion of the Nisqually Delta is contained in the section, Comparative Evaluation of Plans.

To meet the game bird demands of the Nisqually-Deschutes Basins and adjacent Basins, a 5,500-bird farm would be constructed to supply these needs.

The early action projects and programs needed for fish and wildlife enhancement in the Basins are shown in the following tabulation:

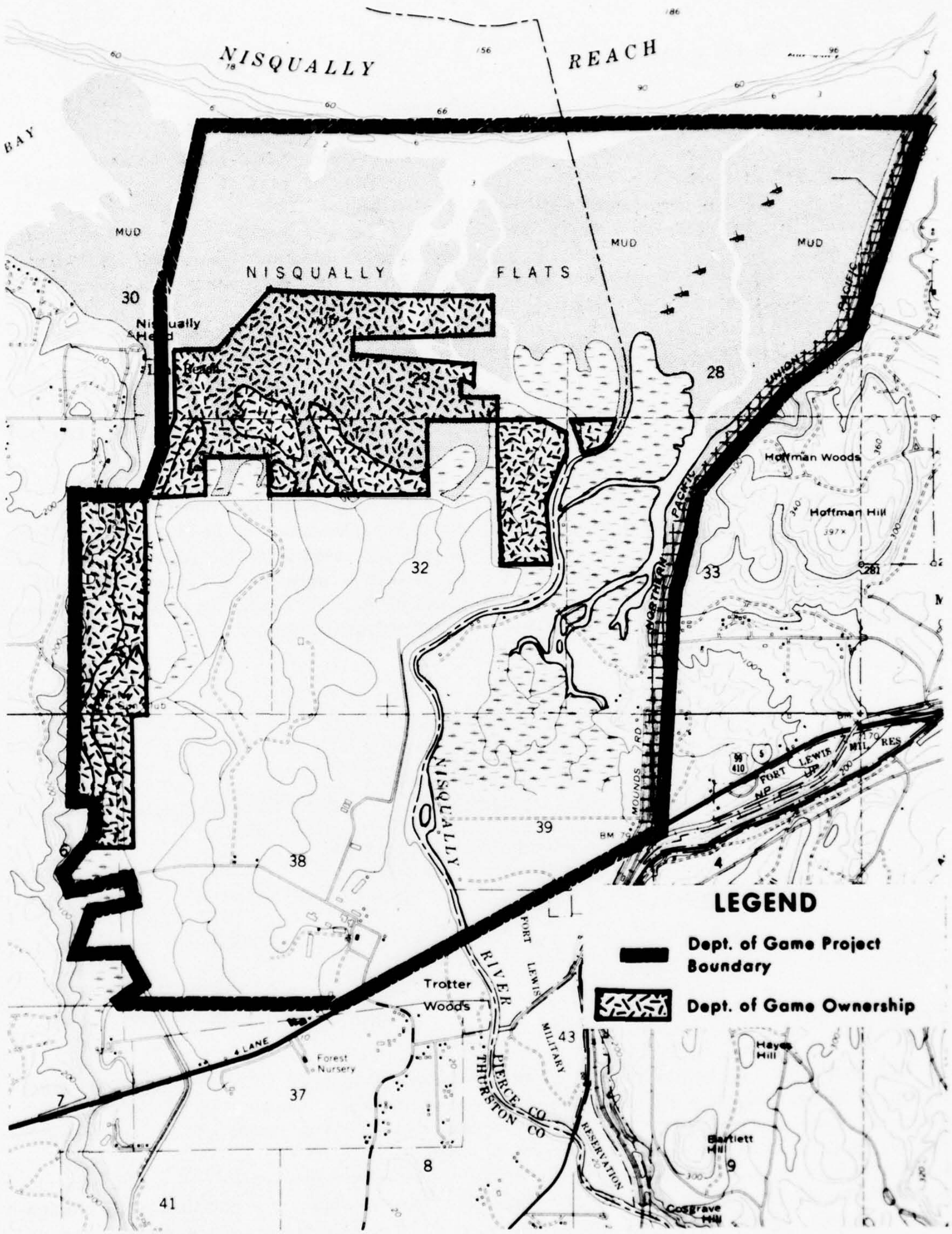


FIGURE 10-5. Projected recreation and wildlife area

Prior to 1980

Projects

a. Acquire and develop access to seven lakes (five Nisqually–two Deschutes).
b. Acquire the 3,000 acres in the Nisqually Delta for waterfowl, recreation, and a natural estuarine area.
c. Acquire and develop two salt water areas–develop portions for waterfowl observation and hunting.
d. Acquire and develop 50 miles of streambank access (30 miles Nisqually–20 miles Deschutes).
e. Acquire and develop 1,000-acre upland bird habitat.
f. Attain streamflow augmentation agreement with cities of Tacoma and Centralia.
g. Provide flood control storage space in Alder Reservoir.
h. Construct 5,500 upland bird game farm.
i. Construct trout hatchery.
j. Construct steelhead and cutthroat rearing pond and hatchery.

Prior to 1980

Programs

k. Conduct stream cross-section measurements.
l. Develop fish toxicants and lake fertilization techniques.
m. Develop fish management for large reservoirs.
n. Develop fish disease control program for lakes.
o. Develop local coop program for habitat development and access.
p. Develop public educational program for utilization of resources.
q. Conduct program studies to determine specific forest-wildlife management.
r. Develop educational program to stress value of spiny-ray fish.

The public access areas noted are in addition to the access areas carried in the recreation plan. The projects and programs for the period 1980 to 2020 are outlined in Appendix XI, Fish and Wildlife. The costs and associated benefits for 1980 plan are shown in the following tabulation:

Fish and Wildlife
Projects and Programs
1970-1980

		Average Annual			
		Costs			
Feature	Investment ($1000)	Interest & Amortization ($1000)	Operation & Maintenance ($1000)	Total ($1000)	Benefits ($1000)
Projects	5,051	234	213	447	661
Programs	127		47	47	839
Total	$5,178		$260	$494	$1,500

1980-2000–The early action program places emphasis on obtaining facilities and natural areas to develop an expanded spawning base for fish. After 1980 the program stresses expansion and improvements of the spawning areas and development of new rearing areas for the young fish. To accomplish the latter objectives would require stream habitat improvement projects on 16 streams, provide fish passage facilities on five streams to open up 60 miles, stream channel clearance for 54 stream miles on 10 streams, develop 10 acres of controlled rearing impoundments; construction of a salmon hatchery and completion of stream cross-section measurements.

To enhance the hunting and wildlife values in the Basin, an expanded public educational program would be required to stress the proper utilization on new management techniques, and the continuing acquisition of key wildlife habitat and hunting areas.

Fish and Wildlife
Projects and Programs
1980-2000

Project	Invest. Cost ($1000)
a. Construct fish passage on five streams, 60 stream miles	365
b. Improve habitat on 16 streams, 38 stream miles	118
c. Clear channels on 10 streams, 54 stream miles	4
d. Construct 10 acres of rearing ponds	55
e. Construct 1 mile of spawning channel	700
f. Construct salmon hatchery	1,020
g. Other fish and game facilities	3,350
Subtotal	$5,612
Programs	
h. Stream cross-section surveys	28
i. Continuation of fish and wildlife programs including range analysis, big game habitat improvement, acquisition of key hunting areas and enhancement of shellfish species	470
Total	$6,090

2000-2020—During this period facilities would be provided to increase chinook, coho, pink, steelhead and searun cutthroat production. Additional projects and programs would be necessary to expand the shellfish harvest, obtain streambank and beach access, and acquire wildlife and wildfowl habitat. The fish and wildlife projects and programs scheduled for development prior to year 2020 are shown in the following tabulation:

Fish and Wildlife
Projects and Programs
2000-2020

Projects	Invest. Cost ($1000)
a. Construct two salmon hatcheries	2,040
b. Develop 45 acres of salmon rearing facilities	247
c. Develop 1 mile of spawning channel	700
d. Additional game fish facilities	3,815
e. Additional wildlife facilities	635
Subtotal	$7,437
Programs	
f. Continuation of fish and wildlife programs including shellfish enhancement	470
Subtotal	470
Total	$7,907

Additional local programs for enhancement of fish and wildlife presently being conducted by the Departments of Fisheries and Game and the Bureau of Sports Fisheries and Wildlife would be continued. Inclusion of the above facilities and completing the programs outlined would meet the fish and wildlife objectives for the Basins.

COST-BENEFIT SUMMARY ALTERNATIVE A

The program and investment costs by resource function are shown in Tables 10-20 and 10-21 with the costs distributed between Federal, State, local, and private interests. Average annual costs and benefits are shown for the projects recommended for implementation prior to 1980. Interest and amortization costs are based on a 100-year economic life with appropriate allowances made for major replacements. An interest rate of 4-5/8 percent was used in the economic analysis. Benefits for municipal and industrial water supply and water quality improvement were assumed equal to annual charges.

TABLE 10-20. Program investment costs,[1] Alternative A, Nisqually-Deschutes Basins ($1000)

Feature	Private	Government Local	Government State	Government Federal	Total
			1970-1980		
Water Quality Control	55	55	165	75	350
Flood Control	0	57	16	9	82
Watershed Management	23,024	8,957	2,875	5,854	40,710
Fish and Wildlife	0	0	127	0	127
Subtotal	$23,079	$ 9,069	$ 3,183	$ 5,938	$ 41,269
			1980-2000		
Water Quality Control	48	48	104	40	240
Flood Control	0	80	23	11	114
Watershed Management	35,578	17,394	3,833	11,326	68,131
Fish and Wildlife	0	0	478	0	478
Subtotal	$35,626	$17,522	$ 4,438	$11,377	$ 68,963
			2000-2020		
Water Quality Control	48	48	132	58	286
Flood Control	0	80	23	11	114
Watershed Management	19,165	586	3,833	10,922	34,506
Fish and Wildlife	0	0	470	0	470
Subtotal	$19,213	$ 714	$ 4,458	$10,991	$ 35,376
Total	$77,918	$27,365	$12,079	$28,306	$145,608

[1] Cumulative annual program costs over the period.

TABLE 10-21. Project investment costs[1] and cost-benefit summary, Alternative A, Nisqually-Deschutes Basins ($1000)

Feature	Investment Costs					Annual Costs			Annual Benefits	
		Government				Interest	Operation			
	Private	Local	State	Federal	Total	& Amortization[2]	& Maintenance	Total	Total	Net
1970-1980										
M&I Water Supply	0	1,290	0	0	1,290	60	108	168	168	0
Irrigation	300	0	0	0	300	10	25	35	35	0
Water Quality Control	775	1,850	925	1,825	5,375	284	5	289	289	0
Navigation[3]	0	891	0	962	1,853	87	5	92	138	46
Power										
Flood Control	0	0	0	0	0	0	0	0	0	0
Watershed Management	0	0	0	0	0	0	0	0	0	0
Recreation	4,400	7,680	5,471	4,400	21,951	1,025	672	1,697	2,590	893
Fish & Wildlife	0	0	5,051	0	5,051	234	260	494	1,500	1,006
Subtotal	$ 5,475	$11,711	$11,447	$ 7,187	$ 35,820	$1,700	$1,075	$2,775	$4,720	$1,945
1980-2000										
M&I Water Supply	0	435	0	0	435					
Irrigation	680	0	0	0	680					
Water Quality Control	1,960	1,550	775	2,475	6,760					
Navigation[3]	0	1,784	0	1,929	3,713					
Flood Control	0	0	0	0	0					
Watershed Management[4]	0	1,519	0	2,821	4,340					
Recreation	6,040	10,570	7,550	6,040	30,200					
Fish & Wildlife	0	0	5,612	0	5,612					
Subtotal	$ 8,680	$15,918	$13,937	$13,265	$ 51,740					
2000-2020										
M&I Water Supply	0	1,167	0	0	1,167					
Irrigation	1,080	0	0	0	1,080					
Water Quality Control	3,000	2,500	1,250	3,450	10,200					
Navigation[3]	0	0	0	0	0					
Flood Control	0	350	0	3,150	3,500					
Watershed Management[4]	0	35	0	65	100					
Recreation	10,730	18,820	13,420	10,730	53,700					
Fish & Wildlife	0	0	7,437	0	7,437					
Subtotal	$14,810	$22,872	$22,107	$17,395	$ 77,184					
Total	$28,965	$50,441	$47,491	$37,847	$164,744					

1 Capital project costs.

2 Of initial investment and major replacement.

3 Costs and benefits for pleasure boating moorage facilities included with Recreation.

4 Investment for structural measures installation only.

SEQUENCE OF DEVELOPMENT—ALTERNATIVE A

The projects and programs of the Comprehensive Plan for the Nisqually-Deschutes Basins are summarized in Table 10-22 by time periods. The project numbers identify features on Figure 10-6. The project, with an asterisk (*) beside the project number, is not shown on Figure 10-6 for varying reasons.

TABLE 10-22. Future projects and programs, Nisqually-Deschutes Basins

PROJECTS PRIOR TO 1980

Municipal and Industrial Water Supply

1. Increase delivery capability of McCallister Springs to 21 mgd capacity.
2. Increase delivery capability of water supply system for Tumwater.
3. Increase delivery capability of water supply system for Lacey.
4.* Increase delivery capability of water supply systems of the small and rural communities.

Irrigation

5.* Installation of individual farm irrigation pumping and sprinkler systems (private) to irrigate 2,700 acres.

Water Quality Control

6. Install secondary treatment facilities at Paradise and Longmire.
7. Provide facilities for adequate treatment of wastes, disinfection and an adequate outfall—Olympia.
8. Provide sewering in Lacey and interception to Olympia treatment plant.
9.* Improvement of waste collection facilities for recreation developments including small boat harbors.

Navigation

10. Deepen West Waterway to 40 feet in Budd Inlet.
11. Development of a small boat harbor—Olympia.

Flood Control

12. Obtain flood control storage in Alder Lake.

Recreation

13. Development of two urban recreation sites north of Olympia.
14. Development of three urban recreation sites near Tumwater.
15. Development of four recreation sites near Long Lake.
16. Development of two recreation sites in Offutt Lake.
17. Development of two recreation sites along Deschutes River between Lake Lawrence and Capitol Lake.
18. Develop a recreation site near Flander Lake.
19. Develop two recreation sites near Lake Lawrence.
20. Develop six salt water shoreline recreation sites between Nisqually Delta and Eld Inlet.
21. Develop two recreation sites near Harts Lake.
22. Develop two recreation sites near Tanawax Lake.
23. Develop one recreation site near Eatonville.
24. Develop three recreation sites near Alder Lake.
25. Develop one recreation site between Alder Lake and Rainier National Park.
26. Develop one recreation site near Mineral Lake.
27. Develop 15 recreation sites in the Snoqualmie National Forest and Rainier National Park.
28. Develop three recreation sites on Nisqually River between Alder Dam and Puget Sound.

Fish and Wildlife

29. Acquire public fishing access on Roy (Muck), Upper Twin, Lower Twin, Bald Hills, Southwick, Hewitt, and Elbow Lakes.
30.* Construct a stream fish hatchery.
31.* Develop steelhead and cutthroat rearing ponds.
32. Acquire and develop saltwater access—Nisqually Flats.
33. Acquire and develop saltwater access—Henderson Inlet.
34. Acquire and develop 50 miles of streambank access.
35. Acquire and develop the 3,000-acre Nisqually Delta for a natural recreation, waterfowl and biotic research area.

PROGRAMS PRIOR TO 1980

Water Quality Control

a. Establish and operate water quality surveillance stations at key salt and fresh water locations. Complete and implement a comprehensive sewerage drainage basin program to provide waste treatment and collection facilities necessary to accommodate expanding population and industrial development.

Flood Control

b. Establish and administer county-wide flood plain zoning measures under flood plain management program.

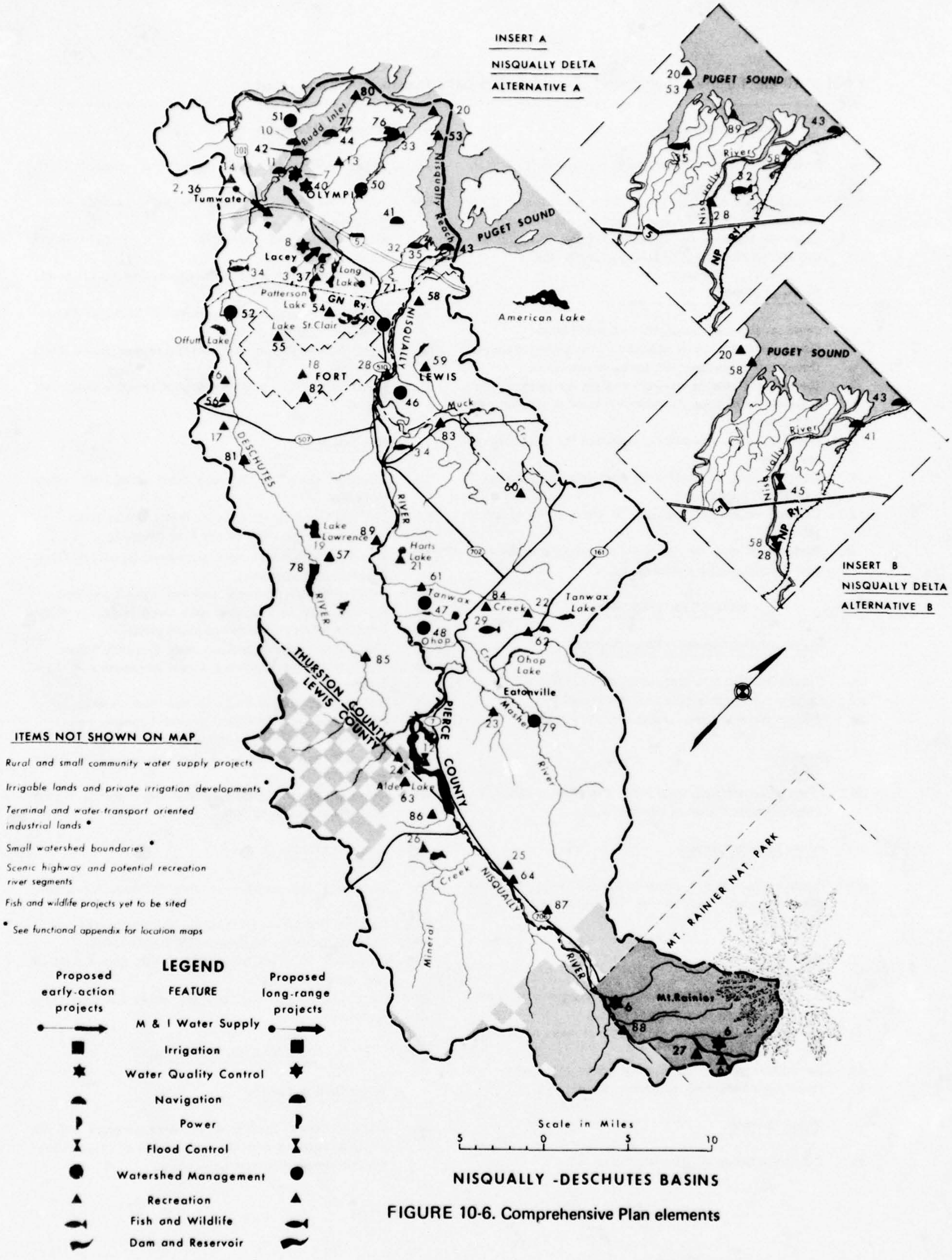


FIGURE 10-6. Comprehensive Plan elements

TABLE 10-22. *Future projects and programs, Nisqually-Deschutes Basins (cont.)*

Watershed Management

c. Provide technical assistance and management for State and Federal lands.
d. Provide technical assistance for on-farm and other private practices. Establish zoning requirements to guide the build-up of intensive land use, changing land use and combinations of land and water use.

Fish and Wildlife

e. Conduct stream cross-section measurements.
f. Develop fish toxicants and lake fertilization techniques.
g. Develop fish management for large reservoirs.
h. Develop fish disease control program for lakes.
i. Develop local coop program for habitat development and access.
j. Develop public educational program for utilization of resources.
k. Conduct program studies to determine specific forest-wildlife management.
l. Develop eductional program to stress value of spiny-ray fish.
m. Perform an inventory of shellfish stocks and potential recreational use by tidelands.

PROJECTS 1980-2000

Municipal and Industrial Water Supply

36. Enlarge the water supply systems at Tumwater.
37. Enlarge the water supply systems at Lacey.
38. Enlarge the small and rural community systems.

Irrigation

39.* Installation of individual farm irrigation systems for irrigating 5,000 acres of new lands.

Water Quality Control

40. Enlarge and expand waste treatment, sewer facilities and adequate outfall at Olympia, Lacey and Tumwater.

Navigation

41. Acquisition of 3,000 acres for water-oriented industrial development on Hawks Prairie.
42. Deepen East Waterway and West Waterway in Olympia Harbor to 46 feet.
43. Small boat harbor development—Nisqually Delta.
44. Small boat harbor development—Budd Inlet.

Flood Control

45. Construct levees in Nisqually Delta.

Watershed Management

46. Small watershed multiple-purpose project—Muck Creek.
47. Small watershed multiple-purpose project—Horn-Tanawax Creek.
48. Small watershed multiple-purpose project—Ohop Creek.
49. Small watershed multiple-purpose project—Nisqually River.
50. Small watershed multiple-purpose project—Henderson Inlet.
51. Small watershed multiple-purpose project—West Budd Inlet.
52. Small watershed multiple-purpose project—Deschutes River.

Recreation

53. Develop seven recreational sites along salt water shoreline.
54. Develop two recreational sites near Lake St. Clair.
55. Develop one recreational site East Olympia.
56. Develop three recreational sites along Deschutes River below Lake Lawrence.
57. Develop two recreational sites near Lake Lawrence.
58. Develop four recreational sites along Nisqually River between Alder Dam and Nisqually Delta.
59. Develop one recreational site near Nisqually Lake.
60. Develop one recreational site near headwaters of Muck Creek.
61. Develop two recreational sites near Seven Lake.
62. Develop two recreational sites near Tanawax Lake.
63. Develop two recreational sites at Alder Lake.
64. Develop two recreational sites upstream of Alder Lake.
65. Develop 20 recreational sites in the National Forest and Rainier National Park.

Fish and Wildlife

66.* Construct fish passage on five streams, 60 stream miles.
67.* Improve habitat on 16 streams, 38 stream miles.
68.* Clear channels on 10 streams, 54 stream miles.
69.* Construct 10 acres of rearing ponds and 1 mile of spawning channel.
70.* Construct salmon hatchery and other fish and game facilities.

PROGRAMS 1980-2000

Water Quality Control

n. Continue water quality surveillance program and the periodic revision and implementation of the comprehensive sewage drainage basin plans.

TABLE 10-22. Future projects and programs, Nisqually-Deschutes Basins (cont.)

Flood Control

o. Continue flood plain management program.

Watershed Management

p. Provide technical assistance for on-farm and other private practices.
q. Provide technical assistance and management for State and Federal lands.

Fish and Wildlife

r. Complete stream cross-section measurements.
s. Continue fish and wildlife programs.

PROJECTS 2000-2020

Municipal and Industrial Water Supply

71. Enlarge McCallister Springs to its ultimate capability.
72.* Increase delivery capability of supply systems at Lacey and Tumwater.
73.* Increase delivery capability of small rural and community systems.

Irrigation

74.* Install the individual farm irrigation facilities for irrigating 8,000 acres of new lands.

Water Quality Control

75.* Construct the municipal, industrial and recreation waste treatment facilities as contained in the plan.

Navigation

76. Construct a small boat harbor—Henderson Inlet.
77. Enlarge small boat harbor at Budd Inlet.

Flood Control

78. Construct Shellrock Ridge Dam and reservoir on Deschutes River.

Watershed Management

79. Small watershed multiple-purpose project—Mashel River.

Recreation

80. Develop two recreation sites along salt water shoreline.
81. Develop two recreation sites along Deschutes River between Lake Lawrence and Capitol Lake.
82. Develop one recreation site near East Olympia.
83. Develop three recreation sites along Muck Creek.
84. Develop one recreation site along Tanawax Creek.
85. Develop one recreation site near Clear Lake.
86. Develop two recreation sites at Alder Lake.
87. Develop three recreation sites upstream from Alder Lake.
88. Develop 30 recreation sites in National Forest and Rainier National Park.
89. Develop five recreation sites along Nisqually River between Alder Dam and Nisqually Delta.

Fish and Wildlife

90.* Construct two salmon hatcheries.
91.* Develop 45 acres of salmon rearing facilities.
92.* Develop 1 mile of spawning channel.
93.* Additional game fish facilities—facilities unknown.
94.* Additional wildlife facilities—facilities unknown.

PROGRAMS 2000-2020

Water Quality Control

t. Continue water quality surveillance program and review of the comprehensive sewage drainage basin plan.

Flood Control

u. Continue flood plain management program.

Watershed Management

v. Provide technical assistance for on-farm and other private practices.
w. Provide technical assistance and management for State and Federal lands.

Fish and Wildlife

x. Continuation of fish and wildlife programs including shellfish enhancement.

PLAN ACCOMPLISHMENTS ALTERNATIVE A

Accomplishments of Alternative A toward meeting identified multiple-purpose needs in the Basins are summarized in Table 10-23.

TABLE 10-23. Accomplishments, Alternative A, Nisqually-Deschutes Basins

Feature	Units	1970-1980			1980-2000			2020		
		Needs	Accomp.	Residual	Needs	Accomp.	Residual	Needs	Accomp.	Residual
M&I Water Supply	MGD	8.5	8.5	0	16.9	16.9	0	33.5	33.5	0
Irrigation	1000 Acre-Feet	5.2	5.2	0	17.1	17.1	0	36.0	36.0	0
Water Quality Control										
Waste	1000 Population Equivalents	166	166	0	315	315	0	561	561	0
Flow										
Nisqually River	cfs	30	30	0	50	50	0	60	60	0
Deschutes River	cfs	10	10	0	17	17	0	20	20	0
Navigation										
Commercial	1000 Short Tons	200	200	0	5,200	1.200	4,000	23,500	4,000	19,500
Pleasure Boats	Wet Moorages	650	230	420[3]	1,430	2,830	(1,400)[4]	2,180	4,040	(1,860)[4]
Electric Power[1]										
Flood Control	$1000 Damage Reduction	69	40	29	110	77	33	160	153	7
Watershed Management										
Flood Prevention	1000 Acres	30.3	30.3	0	30.3	30.3	0	30.3	30.3	0
Rehabilitation and Protection of Watersheds	1000 Acres[2]	635.6	635.6	0	635.6	635.6	0	635.6	635.6	0
Water Management[5]										
Agricultural	1000 Acres	5.3	5.3	0	9.0	9.0	0	11.9	11.9	0
Urban	1000 Acres	39.8	39.8	0	39.8	39.8	0	39.8	39.8	0
Recreation	1000 User-Days	2,590	2,590	0	5,900	5,900	0	12,800	12,800	0
Fish and Wildlife										
Sport										
Fishing	1000 User-Days	401	401	0	1,016	1,016	0	2,009	2,009	0
Hunting	1000 User-Days	67	67	0	154	154	0	206	206	0
Commercial Fishing	1000 Pounds	123	123	0	2,191	2,191	0	4,197	4,197	0

1 Power Needs and Accomplishments projected for the Puget Sound Area only.

2 The *necessary* level of management is assumed to be established throughout the Basins, otherwise some residual could occur.

3 Residual wet moorage needs assumed to be satisfied by private development.

4 Surplus wet moorages provided to satisfy spillover needs from Puyallup Basin.

5 Needs and Accomplishments are cumulative.

As noted in Table 10-23, the Basins needs can be met by Alternative A except for a limited amount of flood control, the streamflow requirements for fish on the Deschutes River, and year 2000 and 2020 commercial port development needs.

Flood protection needs would be only partially met in an area of about 1,000 acres in the high upstream Nisqually River flood plain near Mount Rainier National Park with flood plain management. This area is utilized for limited recreation; however, during the periods of flood hazard there is expected to be little if any activity on the flood plain. Flood plain management would reduce damages projected to occur without flood protection facilities until these facilities can be justified.

Actual streamflow requirements needed on the Deschutes River for fish would be determined upon completion of the streambed cross-section measurements by 1980. If it is determined by these measurements that streamflow should be increased, then development of upstream storage must be reevaluated.

The expansion of the present Olympia Harbor port facilities and the projected new development at the Hawks Prairie site would satisfy the Basins port and water transport related land needs (allocated in Appendix VIII, Navigation) until around the year 1985. After this time part of the remaining navigation related land needs *must be* met at available locations in other basins as so far as possible.

SUMMARY OF PLAN ALTERNATIVE B

Alternative B is the same as Alternative A except for the projected use of the Nisqually Delta. Alternative A projects development of the area for recreational and wildfowl uses. Alternative B discusses the development of a portion of the delta for a navigation port with corresponding terminal and water-oriented industrial land facilities. Based on current and projected trends of land use by the Navigation Appendix, the port facility would be needed after 1980.

Long Range 1980-2020–The projected port development covers approximately 1,300 acres and would be located on Pierce County side of the Nisqually River as shown on Figure 10-7.

The port, terminal and industrial facilities would be constructed by 1985 when projected navigation related land use of the Puyallup River delta would equal available land at that location. As shown on Figure 10-7, a deep draft terminal would be provided through dredging of a waterway east and separate from the main river channel. The terminal would accommodate 12 berths 1,000 feet long at depths from 55 to 85 feet. The interior waterway channel extending from deep water to 3,000 feet inland would be approximately 800 feet wide and 55 feet deep with the outer berths able to serve super-bulk cargo vessels of 71 foot draft.

A unit-train loop would connect with the main lines of the Northern Pacific and Union Pacific Railroads and encircle the bulk and general cargo terminal areas. Although projections of future commerce in terms of specific commodities have not been made beyond 1980, expectations are that bulk cargo including coal, metal ores and some general cargo would be handled at the Nisqually Delta facility. Water transport-oriented industrial use would primarily occur at the Hawks Prairie and Olympia Harbor sites.

The east bank of the Nisqually River would be stabilized through a distance of 16,000 feet, to preserve water quality by isolating the terminal area from the river. The west side of the river would remain in an undisturbed natural state which can be developed for other uses such as recreation, hunting and waterfowl resting area.

Partial development of the 1,300 acres could begin prior to 1980 as significant lead time is ordinarily required to prepare sites for terminal and industrial use where extensive dredging is required as in the case of Nisqually Delta.

The port development would require flood protection in excess of the 100-year flood. Flood control storage in Alder Reservoir, as discussed in Alternative A, would provide the 100-year protection and levees and channelization in the delta would provide protection in excess of 100 years.

The fish and wildlife plan would remain the same as Alternative A except for that portion relating to the Nisqually Delta.

There would be some reduction of projected recreation visitation but this has yet to be evaluated.

Table 10-24 shows all elements of Alternative B and the attendant costs. The output of the programs are complementary to the listed project facilities.

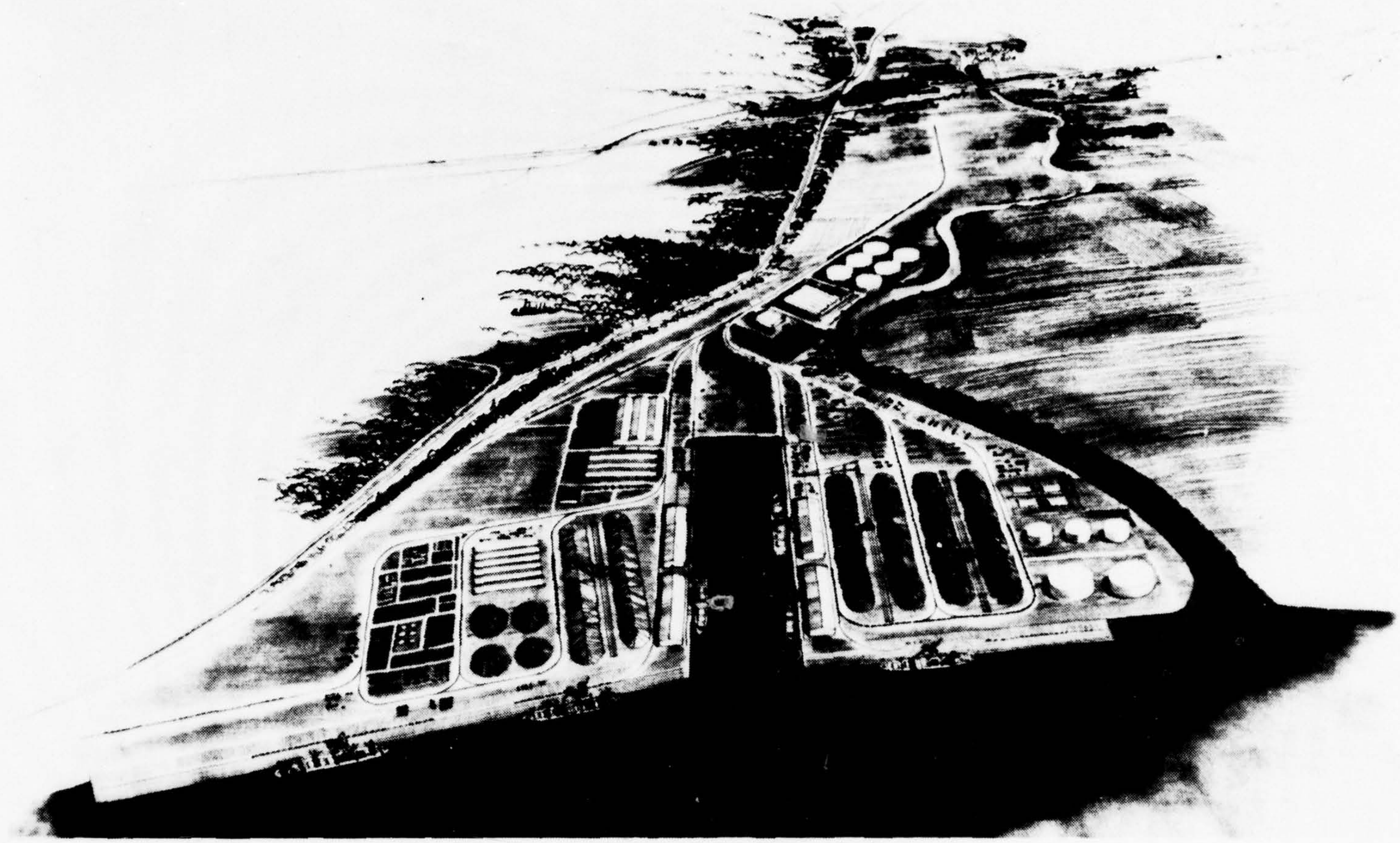


FIGURE 10-7. Artists conception of projected port development, Nisqually Delta

TABLE 10-24. *Comprehensive Plan, Alternative B, Nisqually-Deschutes Basins*

Feature	Item	1970-1980 Investment[1] Costs ($1000)	1970-1980 Average Annual Costs ($1000)	1970-1980 Average Annual Benefits Gross ($1000)	1970-1980 Average Annual Benefits Net ($1000)	1980-2000 Investment Costs ($1000)	2000-2020 Investment Costs ($1000)	1970-2020 Investment Costs ($1000)
Management Programs	Monitoring, Evaluation and							
Water Quality Control	Control Programs	350				240	286	876
Flood Control	Flood Plain Management	82				114	114	310
Watershed Management	Programs	40,710				68,131	34,506	143,347
Fish & Wildlife	Programs	127				478	470	1,075
Total Programs		$41,269				$ 68,963	$ 35,376	$145,608
Nonstorage Projects								
M&I Water Supply	Ground Water Use	1,290	168	168[3]	0	435	1,167	2,892
	Surface Water Use	0	0	0	0	0	0	0
Irrigation	Ground Water Use	273	32	32[3]	0	545	850	1,668
	Surface Water Use	27	3	3[3]	0	135	230	392
Water Quality Control	Waste Treatment and Collection Facilities	5,375	289	289[3]	0	6,760	10,200	22,335
Navigation	Channel Improvements	1,853	92	138	46	6,113	0	7,966
	Small Boat Harbors[1]	(459)[2]	(29)[2]	(43)[2]	(14)[2]	(4,387)[2]	(2,435)[2]	(7,281)[2]
Flood Control	Levees	0	0	0	0	3,000	0	3,000
Watershed Management	Floodwater Damage Reduction, Water Management, Protection and Rehabilitation	0	0	0	0	4,340	100	4,440
Recreation	Land Acquisition, Access and Facilities	21,951	1,697	2,590	893	30,200	53,700	105,851
Fish & Wildlife	Production Enhancement Facilities, Access and Acquisition	2,551	347	1,313	966	5,612	7,437	15,600
Total Nonstorage		$33,320	$2,628	$4,533	$1,905	$ 57,140	$ 73,684	$164,144
Storage Projects								
Flood Control	Alder Dam and Reservoir	0	--	39	39	0	0	0
	Shellrock Ridge Dam and Reservoir	0	0	0	0	0	3,500	3,500
Fish & Wildlife	Alder Dam and Reservoir	0	0	43	43	0	0	0
Total Storage		$ 0	$ 0	$ 82	$ 82	$ 0	$ 3,500	$ 3,500
Total Programs and Projects		$74,589	$2,628	$4,615	$1,987	$126,103	$112,560	$313,252

1 Includes cumulative annual program costs for the period for management features and capital costs for nonstorage and storage projects.

2 General navigation facilities cost and benefits for public small boat harbors only. Total costs and benefits included with Recreation.

3 Average annual benefits assumed equal to average annual costs.

FEATURES OF PLAN ALTERNATIVE B

This section contains discussions of the resource functions which are affected by the developments in the Nisqually Delta under Alternative B only.

Navigation

The Olympia port tonnage volume is not expected to expand markedly due to the lack of adequate space, shallow harbor, and small turning basin. The harbor channel would be dredged to a depth of 40 feet to handle the larger draft vessels. The port is expected to expand their water-oriented terminal and industrial facilities from their present development of 134 acres to their maximum physical boundaries of 540 acres. These developments would satisfy the Basins needs in this category through year 1980.

To meet the year 2000 port and water-oriented industrial land and terminal facility needs, approximately 3,000 acres of land could be acquired by the Port District on Hawks Prairie. Minimal waterfront lands would be acquired for the actual port development while a large back-up area could be developed for terminal facilities and water-oriented industry.

A new port, including terminal facilities and water-oriented industrial lands would be acquired and developed in the Nisqually Delta. The projected port development area would consist of 1,300 acres, all located east of the Nisqually River within Pierce County.

The costs for the projected channel improvements are shown in the following tabulation:

Period	Channel	Channel Depth (feet)	Investment Cost ($1000)	Annual ($1000) Total Cost	Annual ($1000) Gross Benefit	Annual ($1000) Net Benefit
1980	West Waterway					
	Budd Inlet	40	1,853	92	138	46
1980-2000	West Waterway					
	East Waterway	46	1,360			
	Government Waterway	46	2,353			
	Nisqually Delta	78	2,400			
	Total		$7,966			

The remaining land development and terminal facilities costs of the port development have not been estimated as they are beyond the scope of this study.

To meet the salt water small boating needs, small boat harbors and wet moorages would be constructed as discussed in Alternative A. The small boat harbor lands and facilities investment costs, and annual benefits are included in the recreation plan.

Flood Control

Flood plain regulations should be adopted by the county and State to limit or restrict urban development to level of existing flood protection on the Basins flood plains where flood protection is not provided. The regulations would protect against channel encroachment, prevent or minimize material losses, and reduce the cost of relief and rescue occasioned by the unwise occupancy of such flood areas.

An agreement with the city of Tacoma to provide 55,000 acre-feet of storage in Alder Reservoir would provide 100-year protection to 8,000 acres of the 9,000-acre Nisqually flood plain below Alder Dam during the period November 1 through March 1. The city of Tacoma in the past has provided this protection as a result of its power releases in all but a few years since initial operation of Alder Reservoir. The agreement, however, would formally establish this protection. Benefits resulting from the storage protection would amount to $39,000 annually for the flood plain and $33,000 for reduction of damage to fish spawning areas.

To provide protection of the Nisqually Delta port development in excess of the 100-year flood would require localized levees and channelization within the delta proper costing approximately $3,000,000. These facilities would be required at the time the port began operation.

The remainder of the Basins flood protection requirements are contained in Alternative A.

Establishment and maintenance of the flood plain regulations and incorporation of the flood control facilities as discussed would satisfy flood control objectives for the Basins.

Recreation

A compatible recreation plan may be possible in conjunction with the proposed Nisqually Delta port development with some reduction in recreation use. However, further studies of the impact the projected port development would have on the delta must be completed prior to any firm determination.

Investment costs for years 1980, 2000, and 2020, and associated 1980 benefits and operating costs for water-related recreational lands and facilities are presented in the following tabulation. These remain unchanged from Alternative A.

The recreational plan would be coordinated with the State Recreational Plan at all levels of development.

Year	Investment Cost ($1000)	Annual Cost: Investment ($1000)	Annual Cost: OM&R ($1000)	Annual Cost: Total ($1000)	Annual Benefit ($1000)	Net Benefit ($1000)
1980	$21,951	$1,025	$672	$1,697	$2,590	$893
2000	30,200					
2020	53,700					

Fish and Wildlife

Development of a portion of the Nisqually Delta into a commercial port would have an impact upon the projected waterfowl resting, hunting, recreational and natural biotic values of the area. The magnitude of the impact the development would have has yet to be determined, both qualitatively and quantitatively by a special study.

The long-range considerations of this resource upon the Puget Sound Area must be analyzed before a firm determination of the fish and wildlife losses, if any, can be made. For the analysis of Alternative B it is assumed that the fish and wildlife enhancement losses resulting from the port development would have to be made up in other Basins.

The early action projects and programs needed for fish and wildlife enhancement in the Basins are the same as shown in Alternative A with the exception of that portion relating to the Nisqually Delta which is deleted.

The projects and programs for the period 1980 to 2020 are outlined in Alternative A. The costs and associated benefits for the fish and wildlife plan of Alternative B are shown in the following tabulation:

Project or Program	1970-1980 Investment ($1000)	1970-1980 Annual Cost (100 Years @ 4-5/8%) Investment ($1000)	OM&R ($1000)	Total ($1000)	Annual Benefit ($1000)	Net Benefit ($1000)	2000 Investment ($1000)	2020 Investment ($1000)
Project	2,551	107	193	300	517	217	5,612	7,437
Program	127	--	47	47	839	792	498	470
Total	$2,678				$1,356	$1,009	$6,110	$7,907

The difference in costs and benefits between Alternative A and B is due to the deletion of the developmental costs for the Nisqually Delta.

COST-BENEFIT SUMMARY ALTERNATIVE B

The program and investment costs by resource function are shown in Tables 10-25 and 10-26 with the costs distributed between Federal, State, local, and private interests. Average annual costs and benefits are shown for the projects recommended for implementation prior to 1980. Interest and amortization costs are based on a 100-year economic life with appropriate allowances made for major replacements. An interest rate of 4-5/8 percent was used in the economic analysis. Benefits for municipal and industrial water supply and water quality improvement were assumed equal to annual charges.

TABLE 10-25. Program investment costs,[1] Alternative B, Nisqually-Deschutes Basins ($1000)

Feature	Private	Government			
		Local	State	Federal	Total
			1970-1980		
Water Quality Control	55	55	165	75	350
Flood Control	0	57	16	9	82
Watershed Management	23,024	8,957	2,875	5,854	40,710
Fish and Wildlife	0	0	127	0	127
Subtotal	$23,079	$ 9,069	$ 3,183	$ 5,938	$ 40,963
			1980-2000		
Water Quality Control	48	48	104	40	240
Flood Control	0	80	23	11	114
Watershed Management	35,578	17,394	3,833	11,326	68,131
Fish and Wildlife	0	0	478	0	478
Subtotal	$35,626	$17,522	$ 4,438	$11,377	$ 68,963
			2000-2020		
Water Quality Control	48	48	132	58	286
Flood Control	0	80	23	11	114
Watershed Management	19,165	586	3,833	10,922	34,506
Fish and Wildlife	0	0	470	0	470
Subtotal	$19,213	$ 714	$ 4,458	$10,991	$ 35,376
Total	$77,918	$27,365	$12,079	$28,306	$145,608

[1] Cumulative annual program costs over the period.

TABLE 10-26. Project investment costs[1] and cost-benefit summary, Alternative B, Nisqually-Deschutes Basins ($1000)

Feature	Investment Costs					Annual Costs			Annual Benefit	
		Government								
	Private	Local	State	Federal	Total	Interest & Amortization[2]	Operation & Maintenance	Total	Total	Net
			1970-1980							
M&I Water Supply	0	1,290	0	0	1,290	60	108	168	168	0
Irrigation	300	0	0	0	300	10	25	35	35	0
Water Quality Control	775	1,850	925	1,825	5,375	284	5	289	289	0
Navigation[3]	0	891	0	962	1,853	87	5	92	138	46
Power										
Flood Control	0	0	0	0	0	0	0	0	0	0
Watershed Management[4]	0	0	0	0	0	0	0	0	0	0
Recreation	4,400	7,680	5,471	4,400	21,951	1,025	672	1,697	2,590	893
Fish and Wildlife	0	0	2,551	0	2,551	107	240	347	1,356	1,009
Subtotal	$ 5,475	$11,711	$ 8,947	$ 7,187	$ 33,320	$1,573	$1,055	$2,628	$4,576	$1,948
			1980-2000							
M&I Water Supply	0	435	0	0	435					
Irrigation	680	0	0	0	680					
Water Quality Control	1,960	1,550	775	2,475	6,760					
Navigation[3]	0	2,984	0	3,129	6,113					
Flood Control	0	300	0	2,700	3,000					
Watershed Management[4]	0	1,519	0	2,821	4,340					
Recreation	6,040	10,570	7,550	6,040	30,200					
Fish and Wildlife	0	0	5,612	0	5,612					
Subtotal	$ 8,680	$17,358	$13,937	$17,165	$ 57,140					
			2000-2020							
M&I Water Supply	0	1,167	0	0	1,167					
Irrigation	1,080	0	0	0	1,080					
Water Quality Control	3,000	2,500	1,250	3,450	10,200					
Navigation[3]	0	0	0	0	0					
Flood Control	0	350	0	3,150	3,500					
Watershed Management[4]	0	35	0	65	100					
Recreation	10,730	18,820	13,420	10,730	53,700					
Fish and Wildlife	0	0	7,437	0	7,437					
Subtotal	$14,840	$22,872	$22,107	$17,395	$ 77,184					
Total	$28,965	$51,941	$44,991	$41,747	$167,644					

1 Capital project costs.

2 Of initial investment and major replacement.

3 Costs and benefits for pleasure boating moorage facilities included with Recreation.

4 Includes investment for structural measures only.

SEQUENCE OF DEVELOPMENT ALTERNATIVE B

The schedule of development of the projects and programs would be the same as Alternative A with the exception of navigation, flood control and fish and wildlife. These additions and deletions to Alternative A are shown in the inset on Figure 10-6 and discussed as follows.

1970-1980

Fish and Wildlife

B-1. Delete the acquisition and development of the Nisqually Delta for fish and wildlife purposes.

1980-2000

Navigation

B-2. Acquisition and development of the port facility at the Nisqually Delta.

Flood Control

B-3. Construct flood control levees, straighten and deepen channels in the Nisqually Delta.

2000-2020

None

PLAN ACCOMPLISHMENTS ALTERNATIVE B

Accomplishments of Alternative B toward meeting identified multiple-purpose needs in the Basins are summarized in Table 10-27.

As noted in Table 10-27, the Basins needs can be met by Alternative B except for a limited amount of flood control, and some fish and wildlife needs.

Flood plain management would reduce the damages projected to occur without flood control facilities until these facilities are justified.

The fish and wildlife needs projected for the Nisqually Delta would have to be met in other basins. However, a part of these needs could possibly be met with a modified plan developed in conjunction with the port. That portion of the delta west of the Nisqually River would not be required for the projected port and related water-oriented industrial lands. This area would be left as an undisturbed scenic and wildlife area suitable for environmental or other uses.

COMPARATIVE EVALUATION OF ALTERNATIVES A AND B

This section discusses in detail the need and ultimate development of the Nisqually Delta for (a) fish, wilfowl and recreational use and (b) for navigational purposes.

Need and Development—Alternative A

Need—The Nisqually Delta area is one of the most important and one of the few remaining river delta waterfowl areas in the north-south fly lane of the Pacific waterfowl flyway. It is, in fact, the only remaining river delta waterfowl habitat of major significance between the Skagit Bay area and the Columbia River, a distance of approximately 200 miles. With its mild climate and natural production of aquatic plants, it has historically exhibited heavy use in migration and wintering of waterfowl. It is also an area of ecologic and biotic significance, embracing many forms of plant and animal life in addition to traditional wildlife species. Its topography and its geographic features are such that a wide variety of recreational interest can be satisfied. A well-managed waterfowl habitat and recreation area on the Nisqually Delta in public ownership would protect and enhance the present waterfowl, wildlife, and open space values of the area and put to wise use the extensive wildlife and general recreational potential inherent in an area complex of this nature.

A development for wildlife in southern Puget Sound is needed to replace previous losses resulting from concentrated industrial development in basins to the north, as well as to meet projected demands for a greater human population and accelerating outdoor recreational desires. This is the only near similar area in which the potential exists by development to replace the high waterfowl values which have already been lost due to industrial development in the Puyallup Delta between the Puyallup River and Hylebos Creek and in the south Lake Washington-Kent-Auburn valley.

TABLE 10-27. Accomplishments, Alternative B, Nisqually-Deschutes Basins

Feature	Units	1970-1980 Needs	1970-1980 Accomp.	1970-1980 Resid.	1980-2000 Needs	1980-2000 Accomp.	1980-2000 Resid.	2000-2020 Needs	2000-2020 Accomp.	2000-2020 Resid.
M&I Water Supply	MGD	8.5	8.5	0	16.9	16.9	0	33.5	33.5	0
	(1000 Acre-Feet)	(9.6)	(9.6)	0	(18.8)	(18.8)	0	(37.4)	(37.4)	0
Irrigation	1000 Acre-Feet	5.2	5.2	0	17.1	17.1	0	36.0	36.0	0
Water Quality Control										
Waste	1000 Population Equivalents	166	166	0	315	315	0	561	561	0
Flow										
Nisqually River	cfs	30	30	0	50	50	0	60	60	0
Deschutes River	cfs	10	10	0	17	17	0	20	20	0
Navigation										
Commercial	1000 Short Tons	200	200	0	5,200	5,200	0	23,500	23,500	0
Pleasure Boats	Wet Moorages	650	230	420[3]	1,430	2,830	(1,400)[4]	2,180	4,040	(1,860)[4]
Power[1]										
Flood Control	$1000 Damage Reduction	69	40	29	110	77	33	160	153	7
Watershed Management										
Flood Prevention	1000 Acres	30.3	30.3	0	30.3	30.3	0	30.3	30.3	0
Rehabilitation and Protection of the Watershed[2]	1000 Acres	635.6	635.6	0	635.6	635.6	0	635.6	635.6	0
Water Management[6]										
Agriculture	1000 Acres	5.3	5.3	0	9.0	9.0	0	11.9	11.9	0
Urban	1000 Acres	39.8	39.8	0	39.8	39.8	0	39.8	39.8	0
Recreation	1000 User-Days	2,590	2,590	0	5,900	5,900[5]	0	12,800	12,800[5]	0
Fish and Wildlife										
Sport										
Fishing	1000 User-Days	401	401	0	1,016	1,016[5]	0	2,009	2,009	0
Hunting	1000 User-Days	67	40	27	154	127	27	206	179	27
Commercial Fishing	1000 Pounds	123	123	0	2,191	2,191	0	4,197	4,197	0

1 Power Needs and Accomplishments projected for the Puget Sound Area only.

2 The necessary level of management is assumed to be established throughout the Basins, otherwise some residual could occur.

3 Residual wet moorage needs assumed to be satisfied by private development.

4 Surplus wet moorages provided to satisfy spillover needs from Puyallup Basin.

5 Some residual would probably occur resulting from port development. The magnitude has not been determined.

6 Needs and accomplishments are cumulative.

Waterfowl and hunter use of the area are not optimum at present for the following reasons: (1) food is a limiting factor (dairy pasture is not the most productive waterfowl food); (2) duck club ownership and leasing of hunting rights in the area has severely restricted use to only a fraction of its potential. Recent hunter success and a long history of duck club use attests to the area's values as a waterfowl concentration area, however, club hunter success during the 1966 and 1967 seasons averaged over 3.25 ducks per day compared to a State-wide average of 1.4.

As indicated in Appendix XI, Fish and Wildlife, an average of 16,000 waterfowl are present in the Basins during the January annual inventory, following a three-month hunting season in which nearly 20,000 migratory birds are harvested. Waterfowl counts are misleading, as they do not indicate the magnitude of use by a migratory species. Waterfowl numbers build in the fall and early winter while undergoing a constant turnover of birds coming from the north and departing to the south. The Nisqually Delta and adjacent salt water areas are the only waterfowl and waterfowl hunting concentration area within the combined Basins.

The Department of Game anticipates greater concentrated acre-for-acre use of the Nisqually Delta than has been witnessed on the Skagit waterfowl area where peak use exceeds 100,000 ducks and continues from late September through March.

The Nisqually Delta area supports a wide variety of ducks and shore birds, and is used extensively by black brant in the spring northerly migration. Lesser Canada geese and whistling swan are infrequent inhabitants of the area and a flock of 300 snow geese was present for about a week in late January of 1969. Development of the area would include access for beach-combing, clam digging, salmon, trout, and bottom fishing on lower Puget Sound, as well as hunting. Waters off Anderson Island are famous salmon fishing grounds. The natural beauty of the area under this proposal would be preserved and, where possible, would be enhanced by providing development improvements that are complementary to the area as it exists. Sites of historical or other interests would be recognized and included in a comprehensive development plan.

Appendix V, Recreation, and Washington State's Outdoor Recreational Plan cite the acute and critical need for meeting public fishing, hunting, nature study, sight-seeing, and related outdoor recreational demand in or near urban areas where competing interests constitute a significant threat to the remaining wildlife and potential recreational areas.

A decision on the future use of the Nisqually Delta must consider the unique and irreplaceable features of this natural river delta, its estuarine environment, salt water beach, historical significance and its potential for development for wildlife and recreational uses. No other similar area exists in southern Puget Sound.

Development—The Department of Game has underway an active program for acquiring its lands and developing a program for the delta.

The project boundary and present Department of Game ownership for the Nisqually Delta waterfowl development is indicated on Figure 10-3. In general, the area is bounded on the south by Interstate Highway No. 5, on the east by the Northern Pacific-Union Pacific Railway, on the west by McAllister Creek, and the north by Puget Sound. The Department of Game now owns 627 acres as shown on Figure 10-3, virtually all of these lands being outside the diked agricultural lands. A total of approximately 3,000 acres is included within the project boundary, of which about 1,000 acres is diked and farmed.

Development of the area would increase shore birds and migratory waterfowl numbers of the entire Pacific flyway, but would have the greatest impact on an area of about 25-mile radius. In addition to major significance as a wildlife and natural area, the Nisqually Delta offers opportunities for utilization of the Nisqually River, McAllister Creek, Puget Sound, and the unique estuarial and tideland complex of the river delta. Though referred to as a waterfowl game range, the scope of recreational possibilities is in no sense limited to hunting and fishing, but would be truly multiple-use and include those activities for which the area is suitable and that can be accommodated within the general framework of good game management.

Need and Development—Alternative B

Need—The total navigational commerce in Puget Sound is projected to increase from the present 42 million tons to over 259 million tons in the next 50 years. As noted in the Navigation Appendix, the most significant tonnage increases would be in the dry bulk and general cargo categories. The Nisqually Delta port facility would primarily service these commerce categories.

These types of commerce would require new kinds of terminal facilities, cargo handling and back-up areas, transportation and docking facilities. The new containerized cargo and unit trains, which would loop around and through the cargo areas, are in their relative infancy and possess a capability of changing significantly the port development, facilities and operations from that which is presently known.

The Puget Sound is one of the very few natural deep water port areas on the west coast. Projections are that the new fleet of merchant ships presently being constructed would be in excess of 1,100 feet long and with drafts exceeding 50 feet. The natural harbor locations in Puget Sound with adequate channel depth and adequate back-up areas for port development are limited.

The Nisqually Delta, facing the 200-foot depth of Puget Sound and not pre-empted by existing facility development is one of the few remaining natural sites in the Puget Sound for accommodation of the large ships and adequate space for modern terminal and cargo handling facility development. The tracks of the Union Pacific and Northern Pacific Railroads form the eastern boundary and Interstate Highway 5 forms the southern boundary of the proposed port development. The projected port location is ideally suited for rapid ingress and egress of cargo to the major transportation routes.

The Port of Tacoma in the northern part of Pierce County has doubled its terminal facilities since 1964. At the projected rate of growth and demand for terminal facilities of this port, the potential for this development would be utilized by 1985. Due to the limited land availability in Tacoma, requirements would be placed on other existing or new port facilities in the area to assume a portion of this growing demand.

In order to satisfy a share of the projected bulk and general cargo commerce needs for Puget Sound, and meet Tacoma's port expansion needs, a 1,300-acre portion of the 4,000-acre Nisqually Delta should be developed for navigational purposes.

Development—The area to be developed consists of the portion of the tideflats lying in Pierce County. This portion is about 1,300 acres, of a total of 4,000 acres, so that nearly three-fourths of the delta would remain in its undisturbed natural state, except for the existing agricultural uses. The tideflat would be filled from dredging of a waterway and from nearby high ground. The east bank of the Nisqually River would be stabilized and isolated from the terminal area, so that there would be no risk of pollution from the terminal area. The deep draft berths would be on Puget Sound frontage, with lesser draft provided in the waterway. A unit-train loop would connect with the main line railways and encircle the bulk and general cargo terminal areas.

The area west of the Nisqually River would be physically undisturbed by the projected port development. As there would be no large industrial development at the port facility, the natural aesthetic environmental values would not be physically damaged. The remaining delta area could be developed into a natural multiple-purpose recreational and wildlife area.

Summation

The land areas desired for both resource uses is shown on Figure 10-8.

The Nisqually Delta is bounded by high bluffs on the east and west and on the south for practical purposes, by Interstate Highway 5. The portion east of the Nisqually River is in Pierce County; the remainder in Thurston County. Along the bluffs to the east is a main line of the Northern Pacific and Union Pacific Railroads. Roughly half of the delta area is above high tide, and is in semi-agricultural use under private ownership, except for that portion in Thurston County owned by the State Game Department.

With the information available at the present time a rational decision for the projected use of the Nisqually Delta cannot be made. Before any determination can be made, a comprehensive assessment of the projected uses should be completed with the following questions answered:

1. Should the Nisqually Delta be developed for recreational, wildfowl and biotic research purposes only?

2. Should the Nisqually Delta be partially developed for navigational and related industrial purposes?

3. Can and should a compatible navigation port-recreation, wildfowl and biotic research development of the Nisqually Delta be undertaken?

A comprehensive assessment which analyzes the impacts of each of the proposed uses would form the basis of a decision for future use of this area. Accordingly, a moratorium on development for either recreation and wildfowl or navigation purposes is suggested with an in-depth multi-discipline study recommended for early action to resolve the above questions.

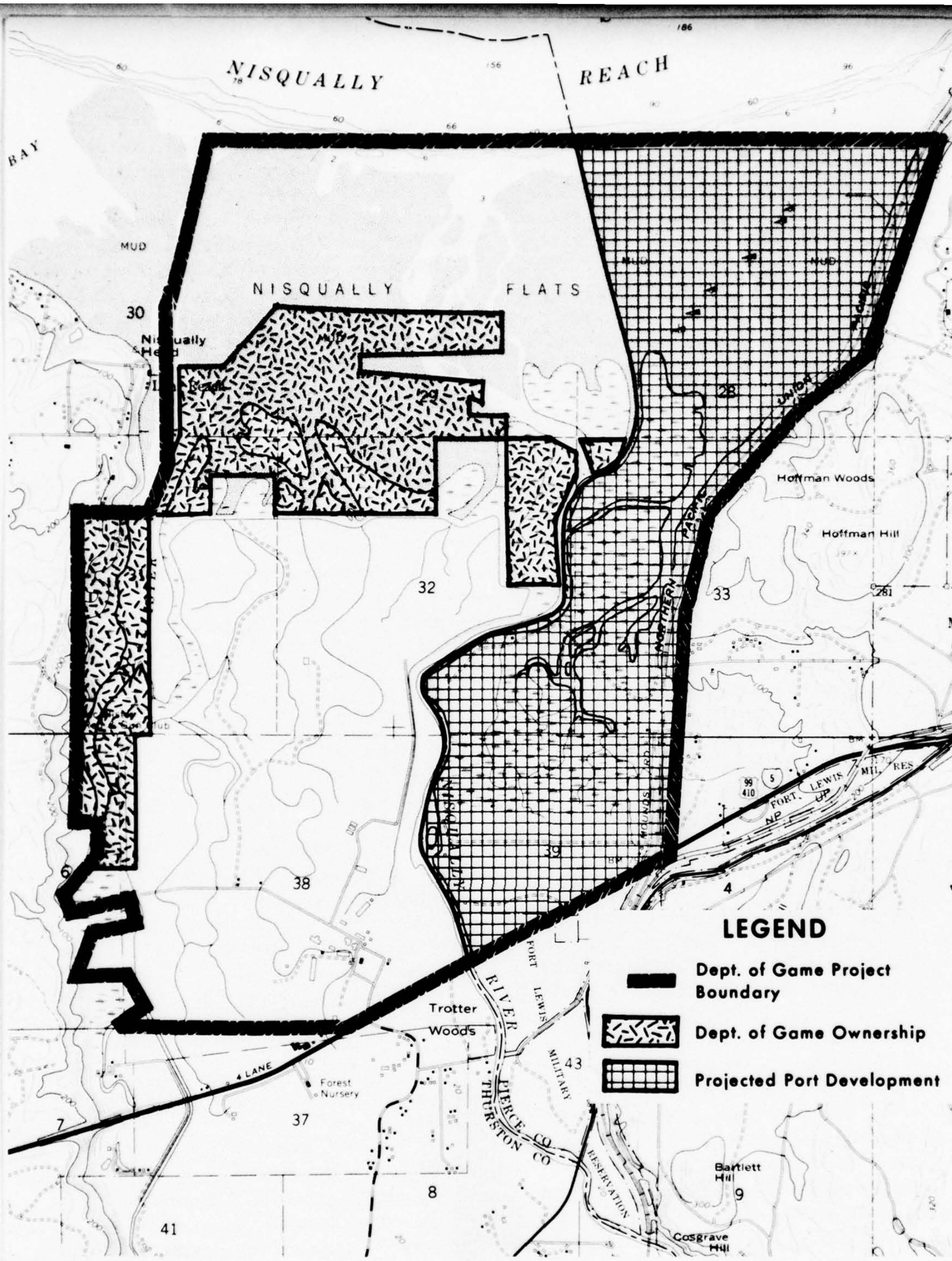


FIGURE 10-8. The Nisqually Delta showing both the projected wildlife and recreation area boundaries and the projected port boundaries.

ALTERNATIVE ELEMENTS

An array of measures were considered in arriving at the suggested plan for the Nisqually-Deschutes Basins. The more important measures which were analyzed and evaluated towards satisfying the needs are discussed in this section along with the reasons for their rejection.

Water Supply Alternatives

There is, in general, a broad range of opportunities for meeting the water supply needs. The Nisqually and Deschutes Rivers flow through generally undeveloped and sparsely settled areas before they empty into Puget Sound. Streamflow runoff for the two rivers is shown in Table 10-28.

Based on water rights, the present annual consumptive diversions are approximately 10,000 acre-feet from the Deschutes and 400 acre-feet from the Nisqually River.

The flow of the Nisqually River is generally controlled by the power operations of Tacoma City Light at Alder and LaGrande Dams and by the city of Centralia diversion below these dams. There are presently no minimum fish flow releases or water rights for fish in the Nisqually River. There is a 2 cfs irrigation water right below LaGrande which is nearly all diverted near Yelm. Future demands on the Nisqually River would be for irrigation, fish flows, and flood control. Only irrigation diversions would be consumptive.

TABLE 10-28. Monthly and annual runoff (1000's acre-feet) (period: 1931-1960)

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
					DESCHUTES RIVER near RAINIER: (89.8 sq. mi.)								
Max. (1956)	16.9	42.8	65.4	48.2	17.4	45.2	21.8	8.0	7.0	3.3	2.6	2.1	280.7
Min.* (1941)	4.5	9.5	13.7	19.2	8.6	8.2	7.2	10.0	5.2	2.9	2.3	4.7	96.1
Mean	6.6	19.8	32.1	31.5	27.9	24.9	17.5	10.0	6.4	3.5	2.5	2.6	185.3
					DESCHUTES RIVER near OLYMPIA: (160 sq. mi.)								
Max.* (1956)	21.6	55.1	83.5	64.1	29.4	70.7	33.8	15.4	13.1	8.4	7.0	6.0	408.1
Min.* (1941)	8.5	13.4	22.6	31.2	17.7	14.7	13.3	17.8	11.3	7.9	6.6	8.6	173.6
Mean	10.5	25.7	43.8	44.9	41.9	39.5	27.5	17.7	12.3	8.4	6.7	6.4	285.3
					NISQUALLY RIVER at LaGRANDE: (292 sq. mi.)								
Max. (1956)	112.6	238.0	243.7	156.0	97.4	104.7	120.5	146.5	119.0	83.6	50.9	53.8	1,526.7
Min.* (1941)	30.6	51.8	79.0	87.9	44.8	42.2	44.8	63.8	41.8	36.9	27.0	38.1	588.7
Mean	61.6	98.7	138.3	122.4	97.0	100.9	94.1	100.4	82.0	57.1	42.0	41.2	1,035.7
					NISQUALLY RIVER near McKENNA: (445 sq. mi.)								
Max. (1956)	137.6	272.9	303.6	196.6	122.4	159.1	155.9	157.6	134.9	88.6	54.5	59.9	1,843.6
Min. (1941)	37.6	66	102	114	66	62	70	76	49	35	28	49	755
Mean	72.5	123.1	177.4	154.8	127.4	132.0	123.1	120.2	94.5	60.0	42.8	44.4	1,272.2

*From correlation.

The Deschutes River has no flow control structures but small irrigation diversions occur throughout the length of the river. There are considerable ground water accretions into the Deschutes River between Rainier and Olympia; various studies indicate that this inflow exceeds 30,000 acre-feet annually. Future demands on the Deschutes River would be for municipal and industrial water supply, irrigation and flow augmentation for fish.

The Basins ground water resources are considered virtually untapped according to Department of Water Resources Bulletin No. 10.

The known surface water demands which must be met from the Deschutes and Nisqually Rivers are shown in Table 10-29.

TABLE 10-29. Summary water demands from Deschutes and Nisqually Rivers (1000's acre-feet)

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Total
						DESCHUTES RIVER at SHELLROCK RIDGE							
Present													
Water Right													
Fish	3.1	3.0	3.1	3.1	2.8	3.1	3.0	3.1	3.0	3.1	3.1	3.0	36.5
Irrig.	--	--	--	--	--	--	--	0.1	0.3	0.4	0.4	0.2	1.4
Other	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	8.4
Total	3.8	3.7	3.8	3.8	3.5	3.8	3.7	3.9	4.0	4.2	4.2	3.9	46.3
1980													
Water Right	3.8	3.7	3.8	3.8	3.5	3.8	3.7	3.9	4.0	4.2	4.2	3.9	46.3
Fish	3.1	11.9	21.5	21.5	19.4	18.4	11.9	6.7	2.4	0	0	0	116.8
Irrig.	--	--	--	--	--	--	--	0.1	0.3	0.4	0.4	0.2	1.4
Total	6.9	15.6	25.3	25.3	22.9	22.2	15.6	10.8	6.5	4.3	4.3	4.0	164.5
2000	Same as 1980												
2020	Same as 1980												
						NISQUALLY RIVER below LaGRANDE							
Present													
Water Right													
M&I	--	--	--	--	--	--	--	--	--	--	--	--	--
Power	44.2	42.8	44.2	44.2	40.4	44.2	42.8	44.2	42.8	44.2	44.2	42.8	521.0
Irrig.	--	--	--	--	--	--	--	.02	.09	0.1	0.1	.06	0.4
Fish	--	--	--	--	--	--	--	--	--	--	--	--	--
Total	44.2	42.8	44.2	44.2	40.4	44.2	42.8	44.2	42.9	44.3	44.3	42.9	521.4
1980													
Water Right	44.2	42.8	44.2	44.2	40.4	44.2	42.8	44.2	42.9	44.3	44.3	42.9	521.4
Fish	9.2	8.9	9.2	9.2	8.3	9.2	8.9	9.2	8.9	9.2	9.2	8.9	108.3
Irrig.	--	--	--	--	--	--	--	--	--	--	--	--	--
Total	53.4	51.7	53.4	53.4	48.7	53.4	51.7	53.4	51.8	53.5	53.5	51.8	629.7
2000													
Water Right	44.2	42.8	44.2	44.2	40.4	44.2	42.8	44.2	42.9	44.3	44.3	42.9	521.4
Fish	9.2	8.9	9.2	9.2	8.3	9.2	8.9	9.2	8.9	9.2	9.2	8.9	108.3
Irrig.	--	--	--	--	--	--	--	.1	.5	.7	.7	.3	2.3
Total	53.4	51.7	53.4	53.4	48.7	53.4	51.7	53.5	52.3	54.2	54.2	52.1	632.0
2020													
Water Right	44.2	42.8	44.2	44.2	40.4	44.2	42.8	44.2	42.9	44.3	44.3	42.9	521.4
Fish	9.2	8.9	9.2	9.2	8.3	9.2	8.9	9.2	8.9	9.2	9.2	8.9	108.3
Irrig.	--	--	--	--	--	--	--	.2	.8	1.2	1.2	.6	4.0
Total	53.4	51.7	53.4	53.4	48.7	53.4	51.7	53.6	52.6	54.7	54.7	52.4	633.7

The additional water demands which must be satisfied from ground and/or surface water in meeting the Basins demands to 2020 are shown in the following tabulation:

(1000 Acre-Feet)

Year	Municipal and Industrial	Irrigation	Total Gross	Total Net
1965	7.4	5.2	12.6	--
1980	15.7	9.9	25.6	13.0
2000	24.6	19.4	44.0	31.4
2020	42.5	34.3	76.8	64.2

Upstream storage would be required to meet projected demands on the Deschutes River.

Municipal and Industrial Water Supply—In arriving at the future municipal and industrial water supply plan the present ground water sources in the Basins were analyzed to determine the adequacy of this resource to meet the water supply projected needs. The supply systems of Olympia and Lacey were analyzed separately and then in combination to determine the adequacy of the source.

Olympia—The capacity of McAllister Springs has been estimated to be in excess of 30 mgd. The present capacity of the pumps is 16 mgd, and the pipeline conveyance system from McAllister Pools to Olympia is 21 mgd. To meet the maximum monthly demand of 20.31 mgd, the pumps would have to be enlarged to the same capacity as the pipeline conveyance system.

Lacey—The city of Lacey obtains its water supplies from a local ground water aquifer known as Woodland Creek drainage. The capacity of the existing system is 1 mgd for both pumps and pipeline conveyance.

The projected municipal and industrial water supply requirements for Olympia and Lacey are shown in the following tabulation:

City and Need	Average Monthly (mgd) Present	1980	2000	2020	Maximum Monthly (mgd) Present	1980	2000	2020
Olympia:								
Municipal	2.80	5.20	8.40	13.80	4.70	7.30	11.70	19.30
Industrial	0.52	0.45	0.48	0.70	0.62	0.56	0.64	1.01
Subtotal	3.32	5.65	8.88	14.50	5.32	7.86	12.34	20.31
Lacey:								
Municipal	0.20	1.30	2.50	4.10	0.90	1.90	3.50	5.80
Industrial	--	--	--	--	--	--	--	--
Totals	3.52	6.95	11.38	18.60	6.22	9.76	15.84	26.11

As can be noted from the preceding tabulation, McAllister Springs has adequate capability to meet the projected maximum monthly requirements of Olympia as well as the city of Lacey. Additional booster pumps would be required for the existing pipeline to increase delivery capability in excess of the maximum monthly requirements. Maximum daily requirements should be met from storage within the distribution system.

Should additional water supplies in excess of 21 mgd be needed prior to year 2020, an additional pipeline would be required. Should the demand increase to over 30 mgd (the present capability of McAllister Springs Pool), shallow wells into the ground water aquifers would be required to provide additional capability in excess of 30 mgd.

The city of Lacey's Woodland Creek drainage is a major ground water basin underlying the city of Lacey. The basin is approximately 18 square miles in size and discharges in Woodland Creek principally through springs. Perennial surface drainage probably does not exceed an average of 2 mgd. The annual

water surplus for the area is about 33 mgd, most of which discharges unseen. Estimates indicate that there is an annual safe yield of at least 25 mgd from the area. The Huntamer system, presently serving Lacey, derives all of its water from this basin. Large production wells should yield at least 850 gpm each (1.2 mgd) and would be around 160 feet deep.

The Huntamer water wells have not shown any pollution as evidenced by coliform bacteria. There is an understandable reluctance among many people in the area to establish well supplies and septic tank drainage fields in the same area; however, wells with adequate surface seals would prevent water from running directly down the outside casing, and this should amply protect the water supply from contamination. The most productive aquifers in Lacey are generally below 80 feet and have hardpan or clay zones above them. Water reaching the aquifers has thus traveled through a great amount of filtering material.

With a large and relatively inexpensive potential of 25 mgd capability, the city of Lacey should retain this source. The cities of Lacey and Olympia could combine their municipal water supply systems, and obtain some system reliability which could be advantageous to both municipalities. This type of opportunity should be explored; however, a survey of the advantages and disadvantages of a combined operation are beyond the scope of this study.

The municipal systems of Lacey and Tumwater and the small rural community systems need updating immediately to meet the State's water supply system standards. This would require enlarging the present pumping facilities, treatment facilities, and distribution systems to handle the peak water demands. General updating of all supply systems would be necessary by 1980 to meet the growth needs of the area.

In summation, the municipal and industrial water supply needs for Olympia, Lacey and Tumwater could be met from existing ground water sources. A detailed comprehensive investigation of the ground water sources has not been made; however, all known studies and analyses indicate there is an ample supply of ground water in the Basins.

Other water supply alternatives analyzed for the Olympia area included storage development on the Deschutes River or Skokomish River. The Skokomish River was not selected due to higher costs associated with transporting water over considerable greater distance. A storage project on the Deschutes River could satisfy municipal and industrial water requirements through the year 2020. However, as the present ground water supply of McAllister Springs and Woodland Creek drainage appears to be adequate to meet projected needs this means was selected.

Appendix VI, Municipal and Industrial Water Supply, projects a greater population increase for the city of Olympia than contained in Appendix IV, Economic Environment. If future water demand occurs as projected in Appendix VI or further development of McAllister Springs becomes unfeasible due to resource limitations or economic considerations, upstream storage on the Deschutes River should be reevaluated.

Alternative Flood Protection Facilities

Nisqually River—Protection from the 100-year flood flows would be provided to the 8,000-acre flood plain below Alder Dam with the adoption of 55,000 acre-feet of storage for flood control purposes. Tacoma City Light has been operating the power generation facilities at Alder Dam so that there is approximately 55,000 acre-feet of storage space available for flood flows during the normal winter flooding period of November 1—March 1. On a few occasions there has been as little as 35,000 acre-feet of storage space available on November 1. However, this has historically been reduced rather quickly after November 1 until there was more than the needed space available. Knowledge of the future operation schedule of Alder Dam and reservoir is not known by the planner. However, unless the existing schedule is changed radically, there could be flood control storage space made available. Agreement for the use of this space would have to be worked out between the flood protection agencies and the city of Tacoma.

Some towns below Alder Dam such as McKenna would prefer protection in excess of the 200-year flood. This protection could be obtained with construction of local levees.

The Nisqually River flood plain is long and narrow and nearly uninhabited. Construction of levees along the river as an alternative to upstream storage to provide even 25-year protection is not a economically feasible alternative. Localized levees could be constructed where needed to provide adequate protection.

Deschutes River—Minimum projected flood control damages on the Deschutes River for 1980 could be reduced through flood plain management. Flood proofing of existing buildings was evaluated as an alternative to major flood protection works for reduction of present and future flood damages.

Approximately $15,000 of the average annual flood damages occurs to buildings. A high percentage of these buildings cannot be economically flood proofed because they are of wood frame construction and would require structural treatment. This alternate would not meet the present or future needs for optimum development and utilization of the Deschutes Basin's flood plains and so is not included.

Flood control levees presently being constructed near Tumwater would provide 50-year protection for that community.

The Deschutes River flood plain is long and narrow, and construction of levees along its length is not practicable. However, localized levees could be constructed as development occurs.

Additional flood protection could be provided with upstream storage. This is discussed further under Management–Storage.

Alternative Fish Flow Measures

Nisqually River–Minimum fish flows need to be established below Alder Dam and particularly below the Centralia Diversion Canal and upstream from power house. Here 13 miles of the Nisqually River is bypassed and flows become critical to fish during the summer months of some years.

The Department of Fisheries has requested from the city of Centralia and city of Tacoma Power and Light that a minimum flow of 150 cfs be provided in this 13-mile stretch of the Nisqually River.

The minimum flow could be provided by purchasing storage from the city of Tacoma from their reservoir behind Alder Dam or it could be obtained by paying the city of Centralia for the power generation foregone if the city cut back their diversions during critical flow periods. Or, the flows could be obtained by modifying the operation of both Alder Dam and city of Centralia's operation to provide the minimum flows.

Historically there have been relatively few times the flow has dropped below the 150 cfs level. Consequently, it appears that an agreement could be made between the Utilities and the Departments of Fisheries and Game to establish a minimum flow of 150 cfs at a point just below the diversion point with minimal disturbance of operation to either power generation facility.

Should an agreement not be reached, a petition to the Federal Power Commission could be submitted by the Departments of Fisheries and Game requesting use of FPC's regulatory powers of recapture on unlicensed power facilities. The single-purpose city of Centralia power facilities have not been licensed by the FPC, and the operation of the power facilities could be altered in favor of multiple-purpose uses should the FPC so rule.

The minimum streamflow for fish cannot be met without storage on the Deschutes River. These are discussed further under Management–Storage.

Alternatives to Nisqually Delta

The Nisqually River Delta area was analyzed as to whether it should be developed into a port facility or developed into a recreational waterfowl hunting area. This is discussed in detail in Comparative Evaluation of Alternatives A and B.

Alternative Storage Measures

A dam and reservoir located at Shellrock Ridge site on the Deschutes River would provide enhancement benefits for flood control, irrigation, fish, recreation, and an alternate source for municipal and industrial water supply.

Reservoir sizes considered ranged from 15,000 to 51,000 acre-feet. The 51,000 acre-foot reservoir was sized to the maximum physical capacity of the site. A reservoir of 90,000 acre-feet would be necessary to meet the fish flows and the other demands 100 percent of the time. The large reservoir was operated to meet the fish flow demands at Olympia 100 percent of the time during the critical summer months and 80 percent of the time during the remainder of the year. In addition to the fish flows, the dam and reservoir would provide: (1) 100-year flood protection for the 2,700-acre Deschutes River flood plain, (2) a full irrigation supply for the 600 acres projected for development, (3) reservoir recreation opportunities for 111,000 recreation-days initially and for ultimate use of 200,000 days, and (4) reservoir fishing opportunities of 26,000 angler-days annually.

Development of the dam and reservoir would require fish and wildlife mitigation measures requiring an investment of $203,000. These measures would include additional rearing facilities and habitat development. The damages far exceed the flow augmentation and fish enhancement benefits at this time.

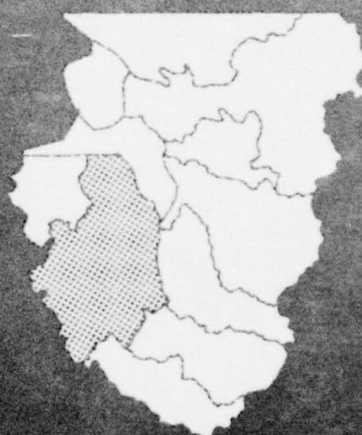
The inclusion of hydro-generation facilities at the reservoir would not be an economical addition as the maximum power head would be less than 100 feet, and the reservoir would be at minimum pool capacity during some years. The Basins hydropower needs are for peaking, which could not be attained

with the minimum head and storage capacity of the reservoir.

With the storage reservoir in operation, there would be adequate streamflow in the Deschutes River at Olympia to meet municipal and industrial requirements for the city of Olympia; however, since the city's present water supply from McAllister Springs appears to be adequate for year 2020 needs, there is not economic justification for including municipal and industrial supply as a function to be served from the reservoir.

For the early action program, the storage reservoir at Shellrock Ridge is not economically justified. It is expected that it would be justified for flood control purpose about the year 2000. The reservoir may be of far more value for fish flow augmentation and possible municipal and industrial water supply after year 2000 than it is presently.

West Sound Basins



WEST SOUND BASINS

DESCRIPTION OF BASINS

GENERAL

The West Sound Basins occupy an area of 2,620 square miles, including 2,022 square miles of land and inland water. The Basins are bounded on the east by the Puget Sound and on the west by the Olympic Mountains. Hood Canal extends 68 miles along the foothills of the Olympic Mountains with a fairly uniform width of 1½ to 2 miles and separates the Basins into two distinct areas, the Olympic and Kitsap Peninsulas. In addition, there are numerous islands, channels, inlets, passages, and bays. The largest islands are Vashon, Bainbridge, Maury, Fox, McNeil, Anderson and Hartstene.

The streams of the Olympic Peninsula are comparatively large and swift; whereas those draining the Kitsap Peninsula and its associated islands are small. Principal rivers draining the east slope of the Olympic Peninsula into Hood Canal are the Skokomish, Hamma Hamma, Duckabush, Dosewallips, Big Quilcene and Little Quilcene. All of these rivers originate in the extremely rugged forested areas of the Olympic National Park and Olympic National Forest. Only the Skokomish River passes through a broad flood plain before entering Hood Canal.

In the extreme headwater areas of certain east Olympic slope streams, mean annual runoff exceeds 160 inches. Runoff decreases rapidly to the east and north, however, as the Olympic Mountains rain shadow intensifies. The lowest precipitation occurs in the vicinity of Port Townsend and the northern extremity of the Kitsap Peninsula. Runoff there is estimated to average less than 10 inches annually. Throughout the lowland areas of the Kitsap Peninsula, annual runoff averages about 25 inches. Mean annual runoff for the entire 2,022-square mile area of land and inland water of the West Sound Basins is estimated to be about 46 inches, or 4.9 million acre-feet.

Streamflow characteristics and other data related to hydrology of the Basin are discussed in detail in Appendix III, Hydrology and Natural Environment. The physiographic characteristics and properties of soils are discussed in more detail in Appendix V, Water-Related Land Resources.

PRESENT SITUATION

Local Economy

The population in the West Sound Basins was estimated at 134,200 for 1967. The principal population centers are Bremerton, Shelton, Port Townsend, Port Orchard, Poulsbo, and Winslow. The historical population is indicated in Table 11-1.

The population within the Basins increased by 16 percent from 1950 to 1967.

TABLE 11-1. Historical population, West Sound Basins

	1940	1950	1960	1967
West Sound Basins	65,000	102,300	110,100	134,200
Principal cities and towns:				
Bremerton	15,130	27,680	28,920	36,170
Port Orchard	1,570	2,320	2,780	3,850
Poulsbo	640	1,010	1,500	1,730
Winslow	--	640	920	1,270
Port Townsend	4,680	6,890	5,080	5,430
Shelton	3,710	5,050	5,650	6,230

Source: Appendix IV, Economic Environment, Appendix V, Water-Related Land Resources.

Land Use

Within the West Sound Basins there are 1,281,400 acres of land and 13,000 acres of fresh water for a total of 1,294,000 acres. The 1967 land use is tabulated in Table 11-2 and shown on Figure 11-1.

TABLE 11-2. Present land use, West Sound Basins

Land Use	Acres	Percent
Forest[1]	1,123,700	87.7
Rural nonfarm	64,200	5.0
Cropland	46,200	3.6
Intensive	42,200	3.3
Rangeland	5,100	0.4
Total	1,281,400	100.0

[1] Includes alpine and other nonforested areas normally associated with forest.

Source: Appendix V, Water-Related Land Resources.

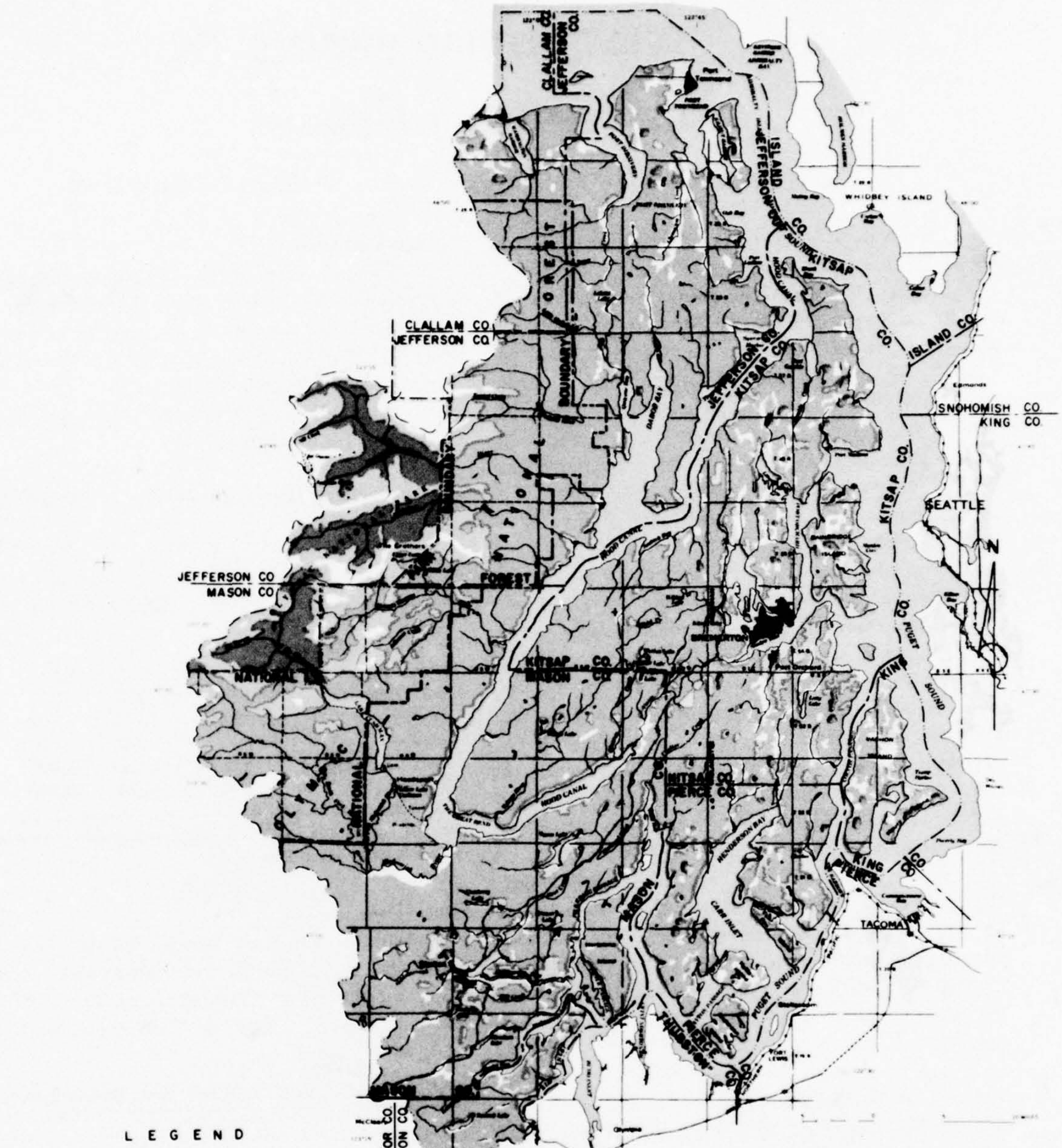


FIGURE 11-1.

WEST SOUND BASINS

GENERALIZED LAND USE MAP

LOCATION MAP

Forests account for 88 percent of the land use. Rural nonfarms comprise 5 percent of the land use, cropland 4 percent and intensive use 3 percent (Figure 11-1). The cropland uses are primarily for forage crops (hay, silage and pasture) which account for 87 percent of this use. The production of berries, vegetables, small grains and nursery products use 5 percent of the cropland while 8 percent of the classified cropland remains idle.

The intensive, urban and built-up land use categories consist of residential, industrial, public and semi-public uses and reserved open space. The intensive use distribution tabulated in acres are as follows: railroads 1,000, roadways 10,000, airports 2,000, and urban (built-up) 29,000, for a total of 42,000 acres.

Land ownership including fresh water areas is shown in Table 11-3.

TABLE 11-3. Land ownership, West Sound Basins

Ownership	*Percent*
Private	46.7
Private corporate	13.9
Federal	28.5
State	9.4
Local government	1.5
Total	100.0

Source: Appendix V, Water-Related Land Resources.

PROJECTED ECONOMY AND LAND USE

Local Economy

The areas of intensive development are in the vicinity of Bremerton, Bainbridge Island, Port Orchard, Shelton, Port Townsend and the shorelines of Hood Canal where summer homes and recreational uses are rapidly expanding.

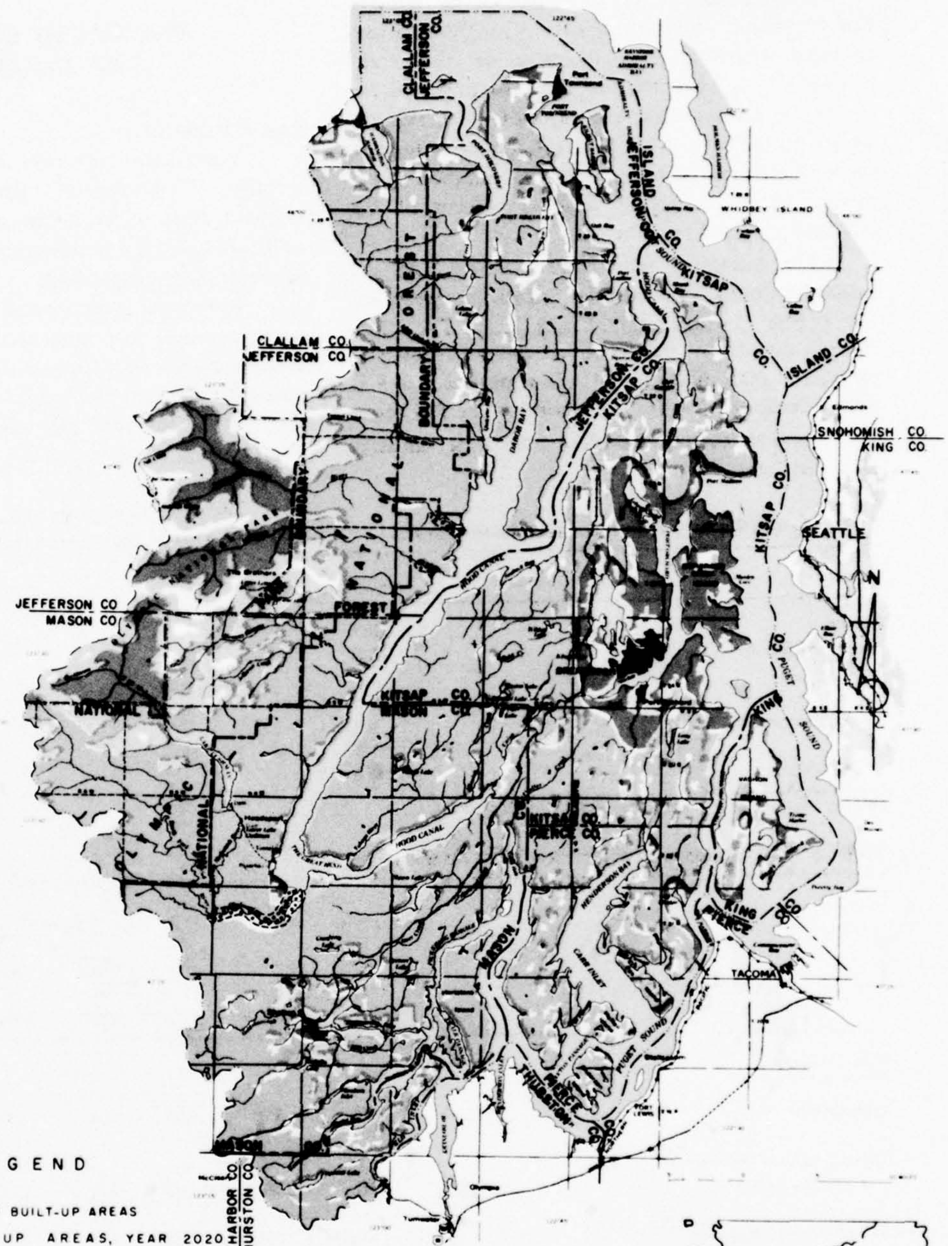
The major growth potentials for the Basins are expected to be in forests, forest products industries, services associated with recreational facilities, and the elements that produce goods for use by the Bremerton Naval Shipyard. The construction of a cross-Sound bridge would materially increase the growth of the Basin.

The economic projections for the West Division and West Sound Basins are tabulated in Table 11-4.

TABLE 11-4. Economic projections, West Sound Basins

					Average Annual Growth Trends (Percent)			
	1963	1980	2000	2020	1963 to 1980	1980 to 2000	2000 to 2020	1963 to 2020
West Division								
Population (1000's)	116	123	170	232	0.4	1.6	1.6	1.2
Gross Regional Product (1,000,000's)	290	498	1,066	1,329	3.3	3.9	1.1	2.7
Employment (1000's)	38	42	58	80	0.6	1.6	1.6	1.3
West Sound Basins								
Population (1000's)	124.2	175.0	374.1	632.7	2.0	3.9	2.7	2.9

Source: Appendix IV, Economic Environment, Appendix V, Water-Related Land Resources.



LEGEND

- PRESENT BUILT-UP AREAS
- BUILT-UP AREAS, YEAR 2020
- FOREST
- RURAL NON-FARM
- CROPLAND
- RANGE
- UNPRODUCTIVE FOREST LAND
- RESERVED PRODUCTIVE FOREST LAND
- GRASS, BRUSH, & BARRENS
- 100 YEAR FLOOD PLAIN

FIGURE 11-2.

LOCATION MAP

WEST SOUND BASINS

GENERALIZED LAND USE MAP

Alternative C2 –2020

Future Land Use

The projected land use of the West Sound Basins for 2020, shown on Figure 11-2, is compared in Table 11-5 with present land use. This land use pattern, based on the construction of a cross-Sound bridge and a bridge between the mainland and southern Whidbey Island, projects for the West Sound Basins an intensive land use density increase from the present 2.9 persons per acre to 6.3 persons per acre by 2020.

TABLE 11-5. Present and projected[1] land use, West Sound Basins (acres)[2]

Land Use	1967	1980	2000	2020
Forest	1,123,700	1,118,200	1,103,000	1,097,800
Rangeland	5,100	5,000	4,900	4,800
Cropland	46,200	45,000	43,000	42,200
Rural nonfarm	64,200	61,200	46,200	36,300
Intensive	42,200	52,000	83,000	100,300
Total	1,281,400	1,281,400	1,281,400	1,281,400
Population	134,200	175,000	374,100	632,700
Density[3]	2.9	3.4	4.5	6.3

[1] Alternative Land Use Pattern C_2, see Puget Sound Area.

[2] Figures are rounded to nearest hundred acres.

[3] Persons per intensive land use acre.

Source: Appendix V, Water-Related Land Resources.

The increase in intensive use would be through decreases in all other uses. The intensive use expansions would occur primarily on the Kitsap Peninsula. Extensive vacation home development, especially adjacent to the numerous marine water channels and embayments, is anticipated for the entire Basin. Projected 2020 intensive use is shown on Figure 11-2.

Due to the occurrence, in numerous locations, of a substantial mantle of glacial basal till, drainage problems are common in the Basins, therefore, careful consideration should be undertaken prior to expansion of existing development or selection of sites for new development. There appears to be sufficient land in the Basins to allow this consideration and planning of growth.

WATER AND RELATED LAND RESOURCE NEEDS

MUNICIPAL AND INDUSTRIAL WATER SUPPLY

General

Surface water is the major source of municipal and industrial water supply in the West Sound Basins, with ground water furnishing a significant portion of the total water supplied.

Bremerton, the largest single water user, obtains its supply from both surface and ground water sources. Union River, Gorst Creek, Anderson Creek, and several other small streams provide the surface water. Port Townsend obtains its water from the Big Quilcene River while Port Orchard utilizes ground water for its supply. The remaining rural communities also rely on ground water for their source of supply.

Industry uses about 70 percent (33.8 mgd) of all water consumed in the Basins. Industrial water users are supplied about equally between municipal and self-supplied sources. Further, industry obtains 91 percent of its water from surface sources.

Present municipal and industrial water use within the West Sound Basins is shown in Table 11-6.

TABLE 11-6. Municipal and industrial water use, 1965, West Sound Basins

System	Estimated Population Served	Surface Water Usage (mgd) Average Daily	Surface Water Usage (mgd) Maximum Monthly	Surface Water Usage (mgd) Maximum Daily	Ground Water Usage (mgd) Average Daily	Ground Water Usage (mgd) Maximum Monthly	Ground Water Usage (mgd) Maximum Daily
MUNICIPAL USE							
Bremerton	42,000	5.35	7.80	10.60	1.15	3.20	5.40
Olympic Gravity Water System (Port Townsend)	7,500	1.5	3.00	4.50	--	--	--
Shelton	5,800	--	--	--	1.00	2.00	3.00
Port Orchard	5,000	--	--	--	0.40	0.80	1.50
Poulsbo Water System	1,700	--	--	--	0.20	0.55	0.90
Winslow Water Supply	1,400	--	--	--	0.18	0.35	0.53
Gig Harbor	1,280	--	--	--	0.10	0.10	0.11
Water District No. 19	1,100	--	--	--	0.07	0.14	0.22
Other rural community systems	37,970	0.42	0.80	1.14	4.00	7.42	10.83
Subtotal	103,750	7.30	11.60	16.20	7.10	14.60	22.50
RURAL-INDIVIDUAL USE	18,150	0.10	0.14	0.20	0.90	1.30	1.80
Municipally supplied:							
Bremerton							
Chemicals, metals, oils		2.40	2.60	2.75	0.50	0.60	0.80
Port Townsend							
Food and kindred		0.01	0.01	0.01	--	--	--
Paper and allied		13.80	15.20	16.60	--	--	--
Shelton							
Lumber and wood		--	--	--	0.40	0.60	0.80
Paper and allied		--	--	--	0.05	0.05	0.05
Self-supplied:							
Lumber and wood		0.78	9.66	18.43	--	--	--
Paper and allied		13.60	15.00	16.30	2.25	2.50	2.70
Food and kindred		--	--	--	0.02	0.02	0.03
Stone, clay, glass		0.02	0.02	0.02	--	--	--
Subtotal		30.60	42.50	54.10	3.22	3.80	4.40
Total	121,900	38.00	54.20	70.60	11.22	18.50	27.10

Source: Appendix VI, Municipal and Industrial Water Supply.

Present and Future Needs

Projected growth in population and industrial development within the West Sound Basins would correspondingly increase municipal and industrial water requirements. However, available data indicates that water needs which are projected to rise from the 1965 level of 49 mgd to 182 mgd in 2020 can continue to be met from sources within the Basins. Table 11-7 shows present and projected water needs.

TABLE 11-7. Projected municipal and industrial water needs, West Sound Basins

Year	Use	Total (Average Daily M.G.D.)	Total (1000's Acre-Feet Annually)	Net Needs[1] (M.G.D.)	Net Needs[1] (1000's Acre-Feet)
1965	Municipal	14.4	16.4		
	Industrial	33.8	38.5		
	Rural-Individual	1.0	1.1		
	Total	49.2	56.0		
1980	Municipal	28	31.4		
	Industrial	63	70.5		
	Rural-Individual	2	2.2		
	Total	93.0	104.1	43.8	48.1
2000	Municipal	52	58.2		
	Industrial	84	94.1		
	Rural-Individual	3	3.4		
	Total	139.0	155.7	89.8	99.7
2020	Municipal	90	100.8		
	Industrial	87	97.4		
	Rural-Individual	5	5.6		
	Total	182.0	203.8	132.8	147.8

[1] Cumulative totals above 1965 use.

Source: Appendix VI, Municipal and Industrial Water Supply.

IRRIGATION

General

The Basins contain about 12,850 acres suitable for irrigation, of which 1,200 acres now are irrigated. Irrigated lands in the West Sound are located in two areas, in the Chimacum Valley near Port Townsend and in the Skokomish River Valley north of Shelton. About 6,600 acres of the potentially irrigable soils are in woodlands.

Of 1,200 acres irrigated in 1966, approximately 950 acres were supplied by surface water and 250 acres by ground water. These 1,200 acres required an average annual volume of 3,100 acre-feet, of which 2,200 acre-feet were considered consumptively used.

Present and Future Needs

A net increase of 1,400 acres of land is expected to be irrigated by the year 2020. Peak surface water diversions are expected to increase from the present 15 cfs to 20 cfs by 1980, 26 cfs by 2000, and 32 cfs by 2020. Future irrigation water net needs are shown in Table 11-8.

TABLE 11-8. Irrigation present status and projected needs, West Sound Basins

Year	New Irrigation (acres)	Total Irrigation (acres)	Total Annual Diversion (ac. ft.)	Net Needs[1] (ac. ft.)
1966		1,200	3,100	--
1980	400	1,600	4,100	1,000
2000	500	2,100	5,400	2,300
2020	500	2,600	6,600	3,500

[1] Cumulative annual diversion above 1966 use.
Source: Appendix VII, Irrigation.

The monthly distribution of the irrigation requirements is shown as percent of annual demand.

May	5%	July	30%	September	15%
June	22%	August	28%	Total	100%

WATER QUALITY CONTROL

General

Most waters are generally low in hardness with average values for the seven stations ranging from 27 to 63 mgd/l. Dissolved solids concentrations are low, with averages ranging from about 42 mg/l to 90 mg/l. Slightly higher dissolved solids are found in Goldsborough Creek where a maximum of 151 mgd/l was recorded. Iron concentrations are low, with averages ranging from 0.0 to 0.3 mg/l.

All the streams within the Basins exhibit high dissolved oxygen values. Averages range from 10.4 to 12.0 mg/l.

Land use and natural factors have kept total phosphate and nitrate concentrations relatively low. All streams average less than 0.2 of these constituents with many phosphate samples of 0.00 mg/l. Nitrates range from very low in the Olympic Peninsula rivers to moderately high in the smaller creeks in the south part of the Basins and the Kitsap Peninsula.

In the southern lowlands dissolved solids normally range between 100 and 200 mg/l, with hardness ranging between 50 to 100 mg/l. In some of the shoreline areas where aquifers may contain traces of sea water, dissolved solids concentrations may exceed 200 mg/l. Nutrient values are generally rather high with phosphates averaging about 0.5 to 0.8 mg/l and nitrates averaging 1 to 2 mg/l. High iron content is seldom reported, although some wells do exhibit slightly high concentrations. In the northern lowlands, the ground water has a dissolved solids content of 200-500 mg/l and hardness of 120-180 mg/l.

Samples taken from the Dosewallips and Duckabush Rivers near Brinnon, from the Big Quilcene River near Quilcene, from the Hamma Hamma at Eldon, and from the Skokomish River near Potlatch indicate very low average coliform counts. Maximum coliform concentrations at these stations are also relatively low—the highest being 430 mpn. Higher coliform values are observed on Goldsborough Creek at Shelton and Chico Creek near Bremerton. Maximum mpn's at these points were 4,600 and 2,400 coliforms per 100 ml, respectively. Table 11-9 summarizes waste generation, treatment and discharges taken from Basin data sampling.

Stream temperatures are significantly low. The maximum summer temperature of 62.6°F (17.0°C) was recorded on Goldsborough Creek. The other stations indicate slightly lower maximums with the Big Quilcene near Quilcene recording a 60°F (15.6°C) maximum temperature.

Smaller streams have appreciable amounts of color at times, attributed largely to organic solutes derived from swamps and poorly drained marshy areas. These colored waters are especially characteristic of much of the surface water on the Kitsap Peninsula. Maximum color values of 50 and 20 units have been recorded on Goldsborough and Chico Creeks.

Suspended sediment concentrations for most streams are relatively low. Sediment data collected from the Skokomish River near Potlatch during 1965 and 1966 indicate an average yearly transported load of about 100,000 tons. It transports as much as 40,000 tons per day when the mean daily discharge exceeds 10,000 cfs. Sediment data for the Dosewallips, Duckabush, and Hamma Hamma Rivers indicate a much lower average annual transported sediment load of about 4,000 tons.

Turbidity is generally low throughout the Basins. Average turbidities for the principal watercourses is less than 10 Jackson Turbidity Units with maximums of only 80 and 70 JTU recorded on the Dosewallips and Skokomish Rivers.

The municipal and industrial wasteload approximates 201,000 population equivalents, of which only about 14 percent is presently removed by waste treatment before being discharged to marine waters. There are no significant waste discharges to fresh waters. The areas receiving the largest quantities of wastes in relation to the total Basins include those waters off Port Townsend (51 percent), Dyes and Sinclair Inlets (28 percent), and Oakland Bay (15 percent).

There are virtually no waste discharges to the streams and rivers. The possible exception may be a few scattered waste discharges to fresh waters from rural homes, recreationists and animals.

TABLE 11-9. Summary of municipal and industrial wastes, West Sound Basins, 1965

Receiving Water	1965 Estimated Population Served	Nonseasonal Untreated Waste PE	Seasonal Untreated Waste PE	Treatment	Nonseasonal Waste Discharge PE	Seasonal Waste Discharge PE
Puget Sound						
Kingston Nike Base and Army Housing	200	225	--	Primary	200	--
Winslow	900	1,100	--	Primary	630	--
Food and kindred	--	--	1,000	None	--	1,000
Creosote	40	50	--	Primary	30	--
Vashon SD	300	320	--	Primary	200	--
Food and kindred	--	--	1,000	None	--	1,000
McNeil Federal Penn.	1,800	2,000	--	None	2,000	--
Port Townsend						
Port Townsend	5,000	6,000	--	None	6,000	--
Paper and allied (400 T/D)	--	96,000	--	None	96,000	--
Fort Flager State Park	--	200	--	Secondary	110	--
Hood Canal						
Port Gamble	100	150	--	Primary	100	--
Bangor NAD	800	1,000	--	Secondary	200	--
Liberty Bay						
Poulsbo	1,500	1,600	--	Primary	1,000	--
Keyport Naval Torpedo Station	1,400	1,500	--	Primary	1,200	--
Dyes and Sinclair Inlet						
Port Orchard	3,000	3,500	--	Primary	3,000	--
Kitsap SD No. 6	600	700	--	Primary	650	--
Kitsap SD No. 5	1,500	2,000	--	Primary	1,300	--
Bremerton No. 1 STP	18,700	23,000	--	Primary	13,800	--
Bremerton No. 2 STP	20,000	24,000	--	Primary	16,000	--
Ships at Dock	2,500	3,000	--	None	3,000	--
Oakland Bay						
Shelton	4,000	4,500	--	Primary	3,400	--
Paper and allied	--	30,000	--	Pond	23,000	--
TOTAL	62,340	201,000	2,000	--	171,800	2,000
Municipal	--	75,000	--	--	52,800	--
Industrial	--	126,000	2,000	--	119,000	2,000

Source: Appendix XIII, Water Quality Control.

Present and Future Needs

Present water quality problems are scattered throughout West Sound and are the results of numerous causes, such as untreated or only partially treated municipal wastes, untreated pulp mill, vessel, and pleasure craft wastes, and log raft debris. Additionally, scattered seasonal homes also contribute to the present pollution of West Sound marine waters.

The general goal for the Basins is to attain the water quality objectives as shown in the "Washington State Water Quality Standards and Implementation Plan, Dec. 1967." The specific quality objectives for various waters are given in Appendix XII.

The present and projected total wastes for 1965, 1980, 2000 and 2020 are shown in Table 11-10.

TABLE 11-10. Present and projected raw wasteloadings, West Sound Basins (1000's PE)

Year	Municipal	Industrial	Recreational	Total	Net Needs[1]
1965	75	128	33	236	208
1980	186	330	54	570	542
2000	308	547	102	957	929
2020	487	659	188	1,334	1,306

[1] Cumulative raw wasteload requiring treatment above that receiving treatment in 1965.

Source: Appendix XIII, Water Quality Control.

NAVIGATION

General

Port Townsend, Port Gamble and Shelton are the principal commercial harbors in the Basins. These harbors accommodate craft transporting general cargo, forest products, bulk petroleum and other dry bulk in foreign import and export as well as coastwise transport of these products.

Many marine water navigation accommodations are provided for transportation and small boat activities. Existing small boat harbor facilities supply 2,324 wet moorages to fulfill recreation needs.

Present and Future Needs

Present and future needs are confined to providing additional wet moorages for small boats. These needs are shown in Table 11-11.

TABLE 11-11. Projected pleasure boating needs and waterborne commerce, West Sound Basins

	Small Boat Wet Moorages			Waterborne Commerce (1000's Short Tons)	
Year	Total	Net Needs[1]	Year	Total	Net Needs
1966	7,980	5,656	1963	239	--
1980	10,920	8,600	1980	--[2]	--
2000	19,600	17,280	2000	--[2]	--
2020	32,900	30,580	2020	--[2]	--

[1] Cumulative needs above the 2,324 wet moorages available in 1966.

[2] No projections made.

Source: Appendix VIII, Navigation.

POWER

General

Two electric power generation facilities exist in the Basin. These are the Skokomish River hydroelectric plants owned and operated by the city of Tacoma. Cushman No. 1 consists of a concrete arch dam with 372,000 acre-feet of usable water. Installed in 1926, the plant has a capacity of 43,200 kw with an approximate average annual output of 157,000 mwh. Cushman No. 2, a smaller concrete arch dam, has a reservoir of 2,000 acre-feet of usable storage. Installed in 1930, the No. 2 plant has a capacity of 81,000 kw and an approximate average annual output of 302,000 mwh.

The Bremerton Naval Shipyard operates the next largest electric power generation facility in the Basin. This non-hydraulic installation has a capacity of 18,000 kw.

Present and Future Needs

There are no economically feasible single-purpose hydropower site locations within the Basins.

Meeting the future power needs in the Basin, as in all of the Puget Sound Area, would require the addition of a number of thermal-nuclear power plants and pumped-storage hydroelectric plants. These needs are discussed in the Area portion of this Appendix and in Appendix IX, Power.

FLOOD CONTROL

General

Flood damages occur on the following streams draining the eastern slopes of the Olympic Mountains:

Skokomish	Dosewallips
Hamma Hamma	Big Quilcene
Duckabush	Little Quilcene

Lands in the flood plain are utilized for agriculture, transportation facilities, summer homes, and a portion of the community of Quilcene. Average annual damages are estimated at $51,000.

Flood problems in the Basins usually coincide with periods of severe rainfall during the winter months. Table 11-12 provides pertinent flood information for the six major streams having flood problems.

Existing flood control measures include flood forecasting and warning service by the U.S. Weather Bureau, flood protective works consisting of bank protection and levees on the Skokomish, Hamma Hamma, Dosewallips and Big Quilcene Rivers and approximately 40,000 acre-feet of storage provided by the city of Tacoma's Cushman Dam and Reservoir on the North Fork of the Skokomish River on an informal basis.

Levees within the Basins only provide a low degree of protection. They do not prevent flooding by large floods, particularly during periods of high tides. The storage provided by the Lake Cushman project is inadequate to control major discharges.

TABLE 11-12. Flooding aspects of the six major West Sound streams

River	Flood Plain Area (acres)	Zero Damage Flow (cfs)	Discharge of Selected Recurrence Interval Flood (cfs)	(years)	Estimated Damages (1966 $)	Estimated Average Annual Damage (dollars)
Skokomish River	4,600	13,000	23,600	11	71,000	27,000
near			30,500	50	191,000	
Potlatch			34,000	100	266,000	
Hamma Hamma	66	4,100	5,810	7	1,600	800
at			9,900	50	7,200	
Eldon			11,600	100	7,900	
Duckabush	70	4,200	6,500	8	6,000	3,000
at			8,960	50	30,000	
Brinnon			14,400	100	49,400	
Dosewallips	250	4,200	8,050	11	56,000	11,600
near			11,700	50	117,500	
Brinnon			13,600	100	142,000	
Big Quilcene	171	1,930	3,400	10	35,800	8,500
(No continuous records)			6,000	100	99,000	
Little Quilcene	93	500	830	10	--	100
near			1,270	50	--	
Quilcene			1,530	100	1,900	
Total	5,310				Total	$51,000

Source: Appendix XII, Flood Control.

Present and Future Needs

The present average annual flood damages of $51,000 occur to croplands, buildings, transportation facilities and flood protective works. The trend of development within the Basins is expected to result in the future growth of damages if additional flood control is not provided. An estimate of future average annual damages is given in Table 11-13.

TABLE 11-13. Project flood damage reduction needs,[1] West Sound Basins

Year	Total ($1000)	Net Needs[2] ($1000)
1966	51	51
1980	68	68
2000	100	100
2020	158	158

[1] Based on 1966 prices and conditions.

[2] Represent flood damages above that reduced by existing measure.

Source: Appendix XII, Flood Control.

Flood control is required for more intensive utilization of flood plain lands. The community of Quilcene should receive at least 100-year level of protection. The flood plain within the Basins should be managed to insure that land use is compatible with the degree of flood protection provided.

WATERSHED MANAGEMENT

General

The need in the West Sound Basins is for implementation of integrated programs and projects for floodwater damage reduction and water management, with rehabilitation and protection of watershed lands regardless of use. The implementation of integrated programs and projects would meet the primary objectives, improve the quality of municipal and industrial water, enhance fish and wildlife habitat and opportunities for recreation, and improve the general environment.

Present and Future Needs

The needs for watershed management in some instances require practices or measures to be implemented on the same area of land. Many measures and treatments become involved in integrated programs and projects. The broad needs for improved technology programs and projects are given under the Area discussion. The watershed management needs for the Basins are tabulated in Table 11-14.

TABLE 11-14. Total watershed management needs, West Sound Basins

Year	Flood Prevention[1] (acres)	Watershed Protection and Rehabilitation (acres)	Water Management: Agricultural (acres)	Water Management: Urban (acres)
1980	44,500	1,281,400	17,100	106,400
2000	44,500	1,281,400	28,600	106,400
2020	44,500	1,281,400	38,100	106,400

[1] Includes flooding on main streams.

Source: Appendix XIV, Watershed Management.

RECREATION

General

Water-based recreation resources within the West Sound Basins include many miles of Puget Sound shoreline, lakes, numerous rivers, and small streams. The mountainous areas of the Olympic Peninsula contains the Olympia National Park. The National Park is characterized by broken and eroded peaks, serrated ridges, alpine valleys, lakes and cascading streams. Dense forests cover this area of outstanding scenic beauty which offers much recreational opportunity.

The Basins are less than a one hour drive from the Seattle metropolitan area which has a population of about 1,000,000. This exposes much of the Basin to heavy recreation use.

In 1964 there were 149 publicly-administered outdoor recreation areas, with 14 administered by the Federal Government, the State 97, the county 26, and cities 12. Of the 460,654 acres of land classified available for public visitation, 73 percent are administered by Federal agencies and 20 percent by State agencies. The Forest Service reported visitation in 1964 amounted to about 144,000 visits. Approximately 8 miles of the Skokomish River is suitable for boating.

Present and Future Needs

The present and future needs for the water-related recreation, expressed in recreation days, is shown in Table 11-15.

TABLE 11-15. Present and projected water-related recreation demand, West Sound Basins (1000's recreation days)

Year	Total	Net Needs[1]
1960	4,000	1,000
1980	8,100	5,100
2000	15,700	12,700
2020	29,200	26,200

[1] Cumulative needs above 3,000,000 days satisfied by facilities existing in 1960.

Source: Appendix X, Recreation.

The existing supply of developed lands is inadequate to satisfy 1960 boating, camping, and picnicking demands. Beaches are of sufficient quantity to satisfy swimming demand past the year 1980, but the supply of swimming pools is inadequate. Existing Forest Service trails meet only 1960 hiking demands. There are enough natural waters to satisfy water-based recreation requirements until at least the year 2010.

In addition to indicated needs, urban parks, scenic routes, waterfront access, harbors of refuge, recreation rivers, special interest areas, interpretive facilities, and open spaces and beaches and trails for activities other than swimming and hiking are necessary to satisfy the recreation and environmental needs of the people.

FISH AND WILDLIFE

General

The West Sound Basins have over 400 miles of accessible streams for the spawning and rearing of anadromous fish. Fish production contributes significantly to the Puget Sound Area commercial and sport fisheries.

Resident game fish populations are important above both man-made and natural anadromous fish barriers. All stream areas below larger impassable obstructions are completely utilized by anadromous salmon, steelhead, whitefish, and mixed nongame fish species.

The Basins contain numerous varieties of game birds and animals. Principal big game animals are deer, elk, and bear. Upland game species of West Sound are pheasant, blue and ruffled grouse, quail and rabbit. Migratory birds include varied species of duck, geese, pigeons, and snipe.

Present and Future Needs

There is a need to retain and expand fishing opportunities for trout, steelhead, salmon and other species in the West Sound Basins. Similarly, there is a need to provide opportunities for hunters commensurate with population growth. The projected fishing and hunting needs are shown in Table 11-16.

TABLE 11-16. Fish and wildlife sport and commercial net needs, West Sound Basins

		1965	1980		2000		2020	
	Unit	Total	Total	Net[1]	Total	Net[1]	Total	Net[1]
Sport Fishing								
Salmon	1000 User-Days	85	141	56	257	172	437	352
Game Fish	1000 User-Days	530	884	354	1,390	860	2,224	1,694
Marine Fish	1000 User-Days	9	12	3	17	8	21	12
Shellfish	1000 User-Days	28	39	11	52	24	67	39
Total		652	1,076	424	1,716	1,064	2,749	2,097
Hunting	1000 User-Days	129	249	120	403	274	497	368
Commercial Fishing	1000 Pounds			278		5,169		8,869

[1] Cumulative need above 1965 activity.

Source: Appendix XI, Fish and Wildlife.

COMPREHENSIVE PLAN

BASIS OF PLANNING

Desires of Local People

During a public hearing held in Olympia on 28 October 1964, local interests expressed a desire for an adequate water supply to serve municipal and industrial needs, development of recreation facilities, augmentation of low water flows and other measures to enhance fish, adequate sewage treatment facilities to maintain adequate water quality, and the development of flood plain zoning. (See Appendix I, Digest of Public Hearings).

Summary of Basin Needs

The needs of the West Sound Basins projected for 1980, 2000 and 2020 are summarized in Table 11-17.

TABLE 11-17. Summary of needs, West Sound Basins

Feature	Units	Cumulative Net Needs[4] 1980	2000	2020
M&I Water Supply	mgd	43.8	89.8	132.2
	(1000 Acre-Feet)	48.1	99.7	147.8
Irrigation	1000 Acre-Feet	1.0	2.3	3.5
Water Quality Control				
Waste	1000 Population Equivalents	542	929	1,306
Flow[1]	cfs	--	--	--
Navigation				
Commercial[2]	1000 Short Tons	0	0	0
Pleasure Boats	Wet Moorages	8,600	17,280	30,580
Power[3]				
Flood Control	$1000 Damage Reduction	68	100	158
Watershed Management				
Flood Prevention	1000 Acres	44.5	44.5	44.5
Rehabilitation and Protection of Watersheds	1000 Acres	1,281.4	1,281.4	1,281.4
Water Management				
Agricultural	1000 Acres	17.1	28.6	38.1
Urban	1000 Acres	106.4	106.4	106.4
Recreation	1000 User-Days	5,100	12,700	26,200
Fish and Wildlife				
Sport				
Fishing	1000 User-Days	424	1,064	2,097
Hunting	1000 User-Days	120	274	368
Commercial Fish	1000 Pounds	278	5,169	8,869

[1] Flow estimates were not developed for West Sound rivers.

[2] No projections developed.

[3] Power needs have been projected for the Puget Sound Area only.

[4] See Water and Related Land Resource Needs for derivation of net needs.

General Planning

A wide range of alternative nonstorage and management opportunities were viewed to meet the projected water needs of the West Sound Basins. These included diversion structures, direct river pumping, desalinization, interbasin water transfer, further ground water utilization, and improved water yields through various watershed management practices. Levees, channelization, diversion, flood plain evacuation, bank protection, and improved land use management practices were considered as possible means of meeting flood control and watershed management needs. Opportunities considered for satisfaction of water quality needs were sewage collection and treatment facilities and minimum flows available to assimilate residual wasteloadings. The water and related land resource was examined in terms of projected land use pattern C_2, (see Projected Land Use) with the land needs of navigation, power, recreation, open space, greenbelts, and fish and wildlife considered within this context.

There are storage sites on a number of rivers which could provide opportunities for hydroelectric power production, flood control and to more fully utilize the resource in meeting water supply needs and minimum streamflow requirements for anadromous and resident fish. Over 1,200,000 acre-feet of aggregate storage could be developed at 17 potential sites within the Basins. With storage there would be sufficient quantities of water to meet projected water supply needs even during a year of extreme low runoff without reducing streamflows below minimums critical for fish. For further information on minimum streamflows for fish see the Area discussion on Fish and Wildlife.

Alternative objectives were considered in developing the Comprehensive Plan. The objectives represented both ends of the spectrum of interests, i.e., economic efficiency and environmental quality as discussed in the Puget Sound Area section of this Appendix. The alternative elements considered in plan formulation are described under Alternative Elements .

The single-purpose Appendices, V through XIV, provided a wide array of solutions. Necessary adjustments were made to these solutions in the formulation of comprehensive plans for the Basins. These adjustments consisted of:

(a) Flood control levee projects, contained in Appendix XII, for the Hamma Hamma, Duckabush, the left bank of the Dosewallips and on the Little Quilcene Rivers are not included in the Plan. These projects would provide protection for intensive land use. Sufficient land is available outside the flood plain for this type of development and the undeveloped flood plain assures that the high quality natural environment of the Basins is retained.

(b) Fish and wildlife measures contained in Appendix XI were modified to a limited extent with additional artificial propagation facilities planned in lieu of several storage projects recommended for flood control and low flow augmentation.

SUMMARY OF PLAN

Early Action, 1970-1980

During this period, municipal and industrial water supply needs of Bremerton and Port Townsend would be satisfied through further utilization of surface water sources. Shelton, Port Orchard, Poulsbo, and other rural communities would utilize ground water sources. Self-supplied industrial water would come from both surface and ground water sources.

About 400 acres of cropland would be placed under irrigation, with water supplied by individual farmers from both surface and ground sources. This increase would make a total of 1,600 acres of land in crop production.

Compliance with Washington State water quality standards would be obtained through installation of adequate collection and treatment facilities by a number of communities and cities in the Basins. Pulp mills would remove settleable solids from mill effluents prior to discharge and would install adequate outfalls and diffusers to achieve maximum dilution and dispersion into marine waters. A water quality surveillance program would be expanded in order to provide an adequate monitoring system with sampling stations on marine and fresh water. A comprehensive sewerage plan would be developed for the Basins.

Navigation needs of the Basins consist of meeting the needs of pleasure boat harbors. Six small boat harbors with over 4,300 wet moorages would be provided for pleasure boaters.

Power needs for the Basins would be satisfied by the Northwest Regional system which is discussed under Power in the Area portion of this Appendix.

A levee project on the Dosewallips River to protect Dosewallips State Park is planned for early action. Flood plain management would provide an effective means of reducing future flood damages through land use zoning of lands in the flood plain, consistent with the levels of protection provided. Floodproofing and warning systems also would be implemented. These measures could contribute significantly to the reduction of future flood damages in the various drainages.

Two small watershed multiple-purpose projects are planned for implementation during this period to achieve damage reduction and drainage improvement. One project is located in the Goldsborough Creek drainage and the other on Chimacum Creek. These projects consist of stabilized channels and outlet control structures. Important complements to the watershed management projects are the programs of technical assistance and management and land treatment and drainage.

Campgrounds, picnic areas, beaches, and boat launching ramps would be developed on existing public lands, together with the acquisition of additional land and water areas to satisfy recreational needs. Additional land and water areas would be acquired along the Puget Sound shoreline to provide badly needed marine parks. Approximately 100 recreation sites are planned for expansion or development prior to 1980.

Land acquisition, including access and fish and wildlife enhancement projects, would be undertaken to increase the opportunities for this form of outdoor recreation. Additional fish hatcheries would be constructed for both resident and migratory fish together with rearing ponds, spawning channels and fish passage improvements. Cross-sectional stream surveys would be undertaken during this period in order to determine the minimum and optimum streamflows required for fish production. Subsequent to these cross-sectional surveys further studies of storage sites may be required, as well as reconsideration of the operation of existing projects.

Long Range, 1980-2020

A storage project is proposed on the Duckabush River to supply anticipated regional municipal and industrial water needs of the Kitsap Peninsula. Distribution would be accomplished using the existing Bremerton system. Other water users within the Basins would continue to develop both ground and surface sources.

An additional 1,000 acres of land would be placed under irrigation during this period with water supplied from ground and surface sources by individuals.

Treatment and collection facilities would be expanded commensurate with the growth in population and industrial development to insure that the State water quality standards are continually met. The water quality monitoring, evaluation, and control program would be maintained.

Navigation development would be limited to satisfying the needs of pleasure boaters. Wet moorages would be provided at 17 small boat harbor projects, with over 21,000 wet moorages between 1980 and 2020.

Power development would probably include pumped-storage at a number of the potential sites within the Basin. Oil or gas-fueled steam electric plants may also be located during this period to meet short-time peaking requirements. Development of nuclear electric generating plants may occur but specific sites have not been determined and would be dependent upon future studies that considered shoreline characteristics nearness to major load centers and impacts on the environment.

Flood control structures envisioned during this period consist of a levee on the Skokomish River to provide protection to agricultural lands and one on the Big Quilcene River to provide protection to the community of Quilcene. Flood plain management would be continued with zoning by the counties to guide future development and prevent unwarranted development in the flood plain.

Further programs and projects would be undertaken to satisfy watershed management needs. These would include 19 multiple-purpose projects and a significant program of technical assistance, land treatment, and water management.

Additional development of campgrounds, picnic areas, and other recreation facilities would be undertaken after 1980 at over 170 sites throughout the Basins, on public lands as well as on private lands, with both public and private sectors participating in the providing of recreation facilities. Portions of the Skokomish River and its North and South Forks may be included in a State system of scenic and recreational rivers for retention in a free-flowing state for public use. Also, the Hamma Hamma, Duckabush, Dosewallips and Big Quilcene Rivers could be included in the system.

Additional fishing opportunities would be

provided through anadromous and resident fishery enhancement measures. A number of fish passage improvements are planned during the long-range period, as well as additional spawning habitat development. Wildlife preservation and enhancement programs begun prior to 1980 would be continued.

Table 11-18 summarizes the West Sound Basins' elements of the Comprehensive Plan, showing the benefits and costs for the early action portion of the Plan, and provides a summary of investment costs by water resource features for the entire 50-year period ending in 2020. The early action portion of the Plan includes programs amounting to $98,744,000 and projects costing $88,995,000, for a total investment of $187,739,000. Program and project investment costs for the 1980-2000 period amount to $271,206,000 and for the 2000-2020 period, $314,250,000, for a total 50-year investment of $773,195,000.

TABLE 11-18. *Comprehensive Plan, West Sound Basins*

Feature	Item	1970-1980 Investment[1] Costs ($1000)	1970-1980 Average Annual Costs ($1000)	1970-1980 Average Annual Benefits Gross ($1000)	1970-1980 Average Annual Benefits Net ($1000)	1980-2000 Investment Costs ($1000)	2000-2020 Investment Costs ($1000)	1970-2020 Investment Costs ($1000)
Management Programs								
Water Quality Control	Monitoring, Evaluation and Control Programs	750	--	--	--	360	480	1,590
Flood Control	Flood Plain Management	125	--	--	--	100	100	325
Watershed Management	Programs	97,404	--	--	--	121,702	120,616	339,722
Fish & Wildlife	Programs	465	--	--	--	800	800	2,065
Total Management		$ 98,744				$122,962	$121,996	$343,702
Nonstorage Projects								
M&I Water Supply	Surface Water	5,850	688	688[4]	--	4,420	2,210	12,480
	Ground Water	2,470	279	279[4]	--	1,770	3,150	7,390
Irrigation	Private Development	50	7	7[4]	--	70	70	190
Water Quality Control	Collection and Treatment	10,900	676	676[4]	--	25,300	37,300	73,500
Navigation	Small Boat Harbors	(8,685)[2]	(556)[2]	(806)[2]	(250)[2]	(17,539)[2]	(26,659)[2]	(52,883)[2]
Power[3]								
Flood Control	Levees	150	11	12	1	1,140	0	1,290
Watershed Management	Floodwater Damage Reduction, Rehabilitation and Protection, and Water Management	1,079	59	150	91	8,055	970	10,104
Recreation	Land Acquisition, Access and Recreation Facilities	62,212	5,405	6,000	595	82,100	133,700	278,012
Fish & Wildlife	Land Acquisition, Access and Enhancement Facilities	6,284	583	1,571	988	13,389	14,854	34,527
Total Nonstorage		$ 88,995	*$7,708*	$9,383	$1,675	$136,244	$192,254	$417,493
Storage Projects								
	Dam and Reservoir, Duckabush River							
M&I Water Supply		--	--	--	--	12,000	--	12,000
Total Storage		--	--	--	--	$ 12,000	--	$ 12,000
Total Programs and Projects		$187,739	$7,787	$9,283	$1,675	$271,206	$314,250	$773,195

1 *Includes cumulative annual program costs for the period for management measures and capital costs for nonstorage and storage features.*

2 General Navigation facilities costs and benefits for public small boat harbors only. Total pleasure boat facilities costs and benefits included with Recreation.

3 Power facilities were not included in basins plan.

4 *Average annual benefits assumed equal to average annual costs.*

FEATURES OF THE COMPREHENSIVE PLAN

Municipal and Industrial Water Supply

Bremerton, Port Townsend, Shelton and Port Orchard are expected to provide the majority of water needed in the Basin in the future. Surface sources would be utilized by Bremerton and Port Townsend to satisfy future needs. Self-supplied industrial water is expected to utilize both surface and ground water sources to fulfill its needs. Other water users would be satisfied by development of ground water. That portion of the Plan dealing with municipal and industrial water supply is discussed by the following periods:

1970-1980—By 1980, water consumption within the Basin is expected to double the 1965 level of use while the population would increase about 45 percent. To meet this demand, all systems are expected to further utilize existing sources. The estimated 1980 demand is expected to reach 93 mgd compared to the 1965 level of 49.2 mgd. The projected average daily water use for the West Sound Basins planned supply and transmission investments and average annual cost are shown in the following tabulation:

Development	Needed by Year	1980 Average Daily Water Use (mgd)	Supply, Transmission & Treatment Investment ($1000)	Average Annual Costs: Interest & Amort.[1] ($1000)	Average Annual Costs: O&M[2] ($1000)	Average Annual Costs: Total ($1000)	Benefits[3] ($1000)
Bremerton		17					
Expansion of existing Union River, Gorst and Anderson Creeks system	1975		1,040	48.6	84	132.6	
Port Townsend		29					
Expansion of existing Big Quilcene River system	1970		2,860	133.6	184	317.6	
Shelton		3					
Additional ground water development	1975		370	28.7	13	41.7	
Port Orchard		2					
Additional ground water development	1975		390	30.2	17	47.2	
Poulsbo and Other Rural Communities		10					
Additional ground water development	1975		1,470	114	36	150	
Self-Supplied Industry		32					
Additional surface water development	1975		1,950	91.2	147	238.2	
Additional ground water development	1975		240	18.6	21	39.6	
Total		93	$8,320	$464.9	$502	$966.9	

[1] Interest and amortization of capital investment costs.

[2] Total incremental increase in annual operation and maintenance costs, including pumping and treatment costs.

[3] Average annual benefits assumed equal to average annual costs.

1980-2000—Increased population growth on the Kitsap Peninsula would require establishment of a regional system facilitated by expansion of the Bremerton water system. To meet the demands in this area a storage project could be constructed on the Duckabush River upstream of the falls near Little Hump tributary. This storage project would provide approximately 160 mgd to the Bremerton system and would allow Bremerton to furnish water to other users on the Peninsula. Studies would be required to determine if the storage project could provide flood control, recreation and low flow augmentation for fishery use. Development of this regional water system on a single river would eliminate the possibility of numerous developments on Olympia Peninsula streams by individual communities on the Kitsap Peninsula. Studies must be made to determine if Port Townsend's surface source can adequately meet the demand without detrimental effects on other resources. Other water users in the West Sound Basins would continue to develop proven sources. Development during this time period is indicated below.

Development	Needed by Year	2000 Average Daily Water Use (mgd)	Supply, Transmission and Treatment Investment ($1000)
Bremerton		30	
Develop storage on transmission system from Duckabush River	1980		13,040
Port Townsend		42	
Expansion of existing Big Quilcene River system	1995		2,340
Shelton		6	
Additional ground water development	1995		540
Port Orchard		3	
Additional ground water development	1995		210
Poulsbo and Other Rural Communities		16	
Additional ground water development	1995		780
Self-Supplied Industry		42	
Additional surface water development	1995		1,040
Additional ground water development	1995		240
Total		139	$18,190

2000-2020—Bremerton and other communities in the northern Kitsap Peninsula would continue to utilize the regional water system developed earlier. Other water users in the Basins would also utilize sources previously developed. The projected average daily use and investment costs for municipal and industrial water supply required by the year 2020 are:

Development	Needed by Year	2020 Average Daily Water Use (mgd)	Supply, Transmission and Treatment Investment ($1000)
Bremerton		48	
No further development planned			
Port Townsend		45	
Expansion of existing Big Quilcene River system	2010		2,210
Shelton		10	
Additional ground water development	2015		780
Port Orchard		5	
Additional ground water development	2015		210
Poulsbo and Other Rural Communities		32	
Additional ground water development	2015		2,160
Self-Supplied Industry		42	
No further development planned			
Total		182	$5,360

Irrigation

Future irrigation development is expected to take place along the fertile bottom lands, or in areas with sufficient ground water supplies, and would depend upon the flood protection provided and land use zoning implemented by county authorities. Irrigation development is anticipated to be by individual farmers pumping from the river or wells. The peak surface diversion demand of 32 cfs by 2020 can be met without adversely affecting other water uses.

This plan provides for a net increase in the West Sound Basins of 1,400 acres of irrigated land over the 50-year planning period for a total of 2,600 acres in the Basins by the year 2020. The majority of water required for this acreage would be from surface sources. Irrigation development provided in the Comprehensive Plan would be:

1970-1980—Increased ground water use planned, together with water pumped directly from the rivers, would be:

1970-1980 New Irrigation Area		Diversion		Net Depletions	
Ground Water Supply (acres)	Surface Water Supply (acres)	Ground Water (acre-feet)	Surface Water (acre-feet)	Ground Water (acre-feet)	Surface Water (acre-feet)
100	300	200	800	100	600

The private investment cost to obtain the ground and surface water is estimated at about $135 per acre for a total investment cost of $50,000 with total average annual charges, including interest and amortization and operation and maintenance costs of $4,000, equal to $7,000. The investment costs include provisions for on-farm sprinkler systems and pumping equipment.

1980-2000—Further diversion is planned with farmers continuing to pump from wells and directly from Basin rivers as shown below.

The private investment cost to obtain these diversions are estimated at $70,000.

1980-2000 New Irrigation Area		Diversion		Net Depletions	
Ground Water Supply (acres)	Surface Water Supply (acres)	Ground Water (acre-feet)	Surface Water (acre-feet)	Ground Water (acre-feet)	Surface Water (acre-feet)
100	400	300	1,000	200	700

2000-2020—Further diversions by individual farmers is planned with water obtained from both surface and ground water sources as shown:

The private investment cost for the diversion is estimated at $70,000.

2000-2020 New Irrigation Area		Diversion		Net Depletions	
Ground Water Supply (acres)	Surface Water Supply (acres)	Ground Water (acre-feet)	Surface Water (acre-feet)	Ground Water (acre-feet)	Surface Water (acre-feet)
100	400	200	1,000	200	700

Water Quality Control

Water quality control elements of the Comprehensive Plan are:

1970-1980—Treatment and outfall facilities would be constructed at Port Townsend, Fort Worden and by the pulp and paper industry in Port Townsend. Interception of industrial shipboard wastes would be installed at the Naval Shipyard in Bremerton and the wood products industry in Shelton would modify its log storage and handling practices.

A large portion of the wastes can be treated by enlargement or replacement of the above facilities. Notwithstanding this partial solution, the scattered nature of future waste sources would necessitate eventual construction of numerous small plants.

A supplementary measure to the above items is the development of a program at the Basin level which would include the establishment of a comprehensive waste management plan taking into consideration projected population growth, establishment of an Area-wide organization for financing, and operating waste collection and treatment installations with supporting research to devise economical small size sewer and treatment installations. Such a program would also deal with the scattered but increasing need for waste collection and treatment from pleasure boats and parks.

Expanded water quality monitoring, evaluation, and control is planned for the fresh and marine waters of West Sound Basins.

The following investment costs of waste treatment and collection facilities called for by 1980 have been estimated for industry, municipalities and recreational development within the Basins. Also shown are the program costs during this period.

Treated wastes are projected to be discharged to marine waters.

Water Quality Control
1970-1980

Feature	Investment Costs ($1000)	Average Annual Costs: Interest & Amortization ($1000)	Average Annual Costs: Operation & Maintenance ($1000)	Average Annual Total ($1000)	Average Annual Benefits[2] ($1000)
Monitoring, Evaluation and Control Program	750[1]				
Industrial Wastes					
Treatment	2,300	120	25	145	145
Municipal Wastes					
Treatment	2,585	124	28	152	152
Sewers	4,815	230	53	283	283
Subtotal	$ 7,400	$354	$ 81	$435	$435
Recreation Waste					
Treatment	1,200	83	13	96	96
Total	$11,650	$557	$119	$676	$676

[1] Cumulative annual program costs for the period.

[2] Average annual benefits assumed at least equal to average annual costs.

1980-2000 and 2000-2020—During these periods, expansion by industry, new developments and growth of urban and recreation areas correspondingly would require that new sewer interception systems be installed and treatment facilities enlarged and/or constructed. Summarized below are estimated investment costs for water quality control.

Water Quality Control
1980-2020

Feature	Investment Costs ($1000) 1980-2000	2000-2020
Monitoring, Evaluation and Control Program	360[1]	480[1]
Industrial Wastes		
Treatment	4,400	8,000
Municipal Wastes		
Treatment	5,800	8,560
Sewers	10,800	15,940
Subtotal	$16,600	$24,500
Recreation Wastes		
Treatment	4,300	4,800
Total	$25,660	$37,780

[1] Cumulative annual program costs for the period.

Navigation

Because of the limited highway and railroad access available in most of the West Sound Basins, no major industrial development or substantial growth in waterborne commerce is expected. The Basin contains many opportunities for boaters and fishermen to fulfill their recreational boating demands. Navigation developments provided in the Comprehensive Plan are:

1970-1980—Over 4,300 wet moorages in six small boat basins are planned by 1980. Studies must be made to assure that the water quality of the Basins is adequately protected as a result of the expected growth. These planned small boat harbor projects are:

Small Boat Harbor Projects
1970-1980

Location	Wet Moorages	Investment Costs ($1000)	Average Annual[1] Costs ($1000)	Average Annual[1] Benefits ($1000)
Port Discovery and Beckett Point	250	500	32	47
Sequim Bay West	940	1,900	121	175
Sinclair Inlet-Annapolis	400	800	52	75
Mats Mats	980	1,965	126	183
Brownsville	650	1,300	84	121
Dyes Inlet	1,090	2,220	142	205
Total	4,310	$8,685	$556	$806

[1] General navigation facilities costs and benefits only based on 50-year economic life amortized at a 4-5/8 percent interest rate. Total pleasure boat facilities costs and benefits included with Recreation.

1980-2000—Demand for additional small boat moorages would require the construction of over 8,700 moorages during this period. A portion of these moorages would satisfy spillover demands from other basins within the Area. Development of small boat basins is dependent upon local interest, availability of funds and other factors. The tentative schedule of public small boat harbor projects for construction between 1980 and 2000 are:

Small Boat Harbor Projects

1980-2000

Location	Wet Moorages	Investment Costs ($1000)
Port Townsend	890	1,800
Oak Bay	700	1,400
Hoodsport	160	350
Manchester	220	450
Bainbridge Island Murden Cove	1,860	3,759
Bainbridge Island Lynwood Center	260	530
Hood Canal—Coon Bay	1,090	2,220
Hood Canal—Duckabush	1,360	2,780
Hood Canal—Union	2,170	4,300
Total	8,710	$17,539

2000-2020—The increasing demand for small boat moorages would require the full development of sites found within the Basins to be suitable for small boat harbors. Projects providing wet moorages planned for public development are:

Small Boat Harbor Projects

2000-2020

Location	Wet Moorages	Investment Costs ($1000)
Kingston	740	1,499
Quilcene Bay—East Side	1,340	2,740
Bainbridge Island—Fletcher Bay	260	530
Marrowstone Island—East Side	2,980	6,000
Hood Canal—Bywater Bay	2,500	5,000
Hood Canal—Thorndyke Bay	1,800	3,650
Hood Canal—Warrenville	1,980	3,980
Hood Canal—Anderson Cove	1,620	3,260
Total	13,220	$26,659

Power

As previously stated, power production and distribution facilities would be planned on a regional basis. The power needs of the West Sound Basins would be met by facilities in the Puget Sound Area and by importation.

Flood Control

The Comprehensive Plan provides for a reduction of flood damages in the Dosewallips, Skokomish, and Big Quilcene River Basins. Flood protection objectives for the Basins would be met by the elements proposed in this Plan. Industrial and urban lands within the Basin would be provided 100-year level, agricultural lands requiring at least 25-year level and lands along the flood plain to be used for parks, golf courses, and general recreation 10-15 years.

Flood plain management measures such as floodproofing, flood plain zoning, or other positive means of land use control would be implemented. Sufficient lands are considered available within the West Sound Basins to preclude the necessity of intensive development in the flood plain.

Elements of the Comprehensive Plan dealing with flood control are:

1970-1980—A flood control project to protect the Dosewallips State Park at the mouth of the Dosewallips River would be constructed. The project would consist of a levee to protect the area from floods having a frequency of once in 50 years. Flood plain management would be initiated on the rivers within the Basin. The following tabulation summarizes the early action flood control programs and projects:

Flood Control Element	Design Capacity (cfs)	Investment Costs ($1000)	Average Annual Costs: Interest & Amortization ($1000)	Average Annual Costs: Operation & Maintenance ($1000)	Average Annual Costs: Total ($1000)	Average Annual Benefits ($1000)
Dosewallips River Levee—Right Bank 1,700 Feet	12,000	150	7	4	11.0	12.0
Flood Plain Management		125[1]				
Total		$275	$7	$4	$11.0	$12.0

[1] Cumulative program costs over the period.

1980-2000—During this period the only structural features anticipated are levees on the Big Quilcene and Skokomish Rivers. The levee on the Big Quilcene would be on the right bank to protect the community of Quilcene at an estimated cost of $240,000. Consideration should be given to protect urban developments on the left bank at this time. On the Skokomish River, levees approximately 5 miles in length would protect 3,000 acres of agricultural land and would have an estimated cost of $900,000. Flood plain management would continue at an estimated cost of $100,000 for the period.

2000-2020—Flood plain management would continue at an estimated cost of $100,000 for the period.

Watershed Management

With the exception of beach erosion problems, watershed management needs in the West Sound Basins would be satisfied by the progressive development of 21 small watershed projects and the continuation and acceleration of land treatment practices. These small watershed projects are for floodwater damage prevention, rehabilitation and protection, and water management, and would make areas of the flood plains suitable for more efficient agricultural use. These projects would complement main-stem projects and require their construction in order to be fully effective. Upgrading of existing facilities and more intensive application of recurring and nonrecurring land treatment practices would be required throughout the Basins. Ongoing watershed management programs which provide some degree of technical assistance and financial participation would be continued.

1970-1980—Two projects are recommended for initiation prior to 1980 in order to remedy existing floodwater and water management problems. Following are descriptions of the projects planned for early action:

Goldsborough Creek Watershed—Goldsborough Creek is the principal stream of this watershed of approximately 60 square miles. The area is 90 percent forested and the economy is based on forest products. The terrain is low and mountainous. The Coffee Creek Valley is the principal agricultural area. Shelton is the major city and the industry is centered there.

The project is designed to prevent flooding in agricultural and urban areas and provide water

management improvements on agricultural lands. The watershed contains 38,501 acres of which 907 acres are cropland, 34,599 acres are forest, 2,906 acres are rural nonfarm and urban, and 89 acres are in miscellaneous uses.

The works of improvement would consist of 5 miles of improved and stabilized channel and one floodwater retarding structure for floodwater control. Structural measures installation cost is estimated to be $779,000, of which the Federal share is $503,000 and the local share is $276,000. Benefits from damage reduction and water management would provide a benefit-cost ratio of 1.2 to 1. To achieve benefits made possible by the structural works and other management, during a 15-year period local interests would install necessary land treatment measures for erosion control and flood management costing approximately $64,300, water management measures expected to cost $61,100, and forest protection and management practices costing $746,300, for a total of $871,700. The total cost of installing the structural measures and the land treatment measures is $1,650,700.

Chimacum Creek Watershed—Chimacum Creek flows to the north and outlets into Port Townsend Bay near the city of Port Townsend. The flood plain is used principally for cultivated agriculture, while the major portion of the upland is covered with a dense forest of fir, alder, and native brush.

Water problems of the watershed are mainly due to inadequate channels to carry flood and drainage water. Water control structures are necessary to stabilize the water table in the areas of organic soil.

The project is designed for flood prevention in agricultural and urban areas, and water management improvements on agricultural lands. The area contains 22,326 acres, of which 4,257 are cropland, 16,981 acres are forest, 862 acres are rural nonfarm and urban, and 226 acres are in miscellaneous uses. The structural works of improvement would consist of 16 miles of improved and stabilized channel, eight water control structures, and one debris basin for the detention and control of stream sediment.

Installation cost is estimated to be $300,000, of which the Federal share is $233,000 and the local share is $67,000. Benefits from damage reduction and water management would provide a benefit-cost ratio of 5.9 to 1. To achieve benefits made possible by the structural works and other management during a 15-year period, local interests would install necessary land treatment measures for erosion control and flood management costing approximately $814,800, water management measures expected to cost $507,000, and forest protection and management practices costing $366,300, for a total of $1,688,700. The total cost of installing the structural and land treatment measures is $1,988,700.

Programs tabulated below include the complimentary features to the projects discussed above and other on-farm and urban on-site practices required in the West Sound Basins.

Non-Federal costs include the present costs of on-going programs of development with redirection and acceleration to meet the needs. Total costs are shown.

Watershed Management Practices
1970-1980

Practice	Area (acres)	Cost ($1000)
Technical assistance		
and management	1,175,018	
Federal, regular		19,764
Federal, accelerated		205
Subtotal		$19,969
Installation of practices (non-Federal)		
State and corporate		
management		19,718
Land treatment	804,009	6,108
Water management		
Agricultural	17,138	3,743
Urban	35,456	47,866
Subtotal		$77,435
Total		$97,404

1980-2000—The projects and programs scheduled for this period would be:

Watershed Management Practices
1980-2000

Program	Area (acres)	Cost ($1000)
Technical assistance and management	1,175,018	
Federal, regular		33,142
Federal, accelerated		1,637
Subtotal		$ 34,779
Installation of practices (non-Federal)		
State and corporate		26,291
Land treatment	804,009	8,144
Water management		
Agricultural	11,425	2,388
Urban	37,111	50,100
Subtotal		$ 86,923
Total		$ 121,702

Project	Area (acres)	Structural Measures Installation Costs
Skookum Creek	54,301	290,000
Northwest Shelton	102,601	260,000
South Fork Skokomish	81,921	3,000,000
North Hood Canal	32,839	85,000
Carr Inlet	79,820	580,000
Vashon Island	23,099	570,000
West Kitsap area	76,338	700,000
East Kitsap area	95,120	1,200,000
Quilcene	77,645	140,000
East Jefferson	126,166	540,000
Sequim Bay	22,459	110,000
Johnson Creek	15,517	580,000
Total	787,826	$8,055,000

2000-2020—The projects and programs recommended for implementation during this period are shown in the following tabulation:

Watershed Management Practices
2000-2020

Program	Area (acres)	Cost ($1000)
Technical assistance and management	1,175,018	
Federal, regular		36,336
Federal, accelerated		955
Subtotal		$ 37,291
Installation of practices (non-Federal)		
State corporate		26,291
Land treatment	804,009	8,144
Water management		
Agricultural	9,521	3,257
Urban	33,802	45,633
Subtotal		$ 83,325
Total		$120,616

Project	Area (acres)	Structural Measures Installation Costs
Isabella	21,902	100,000
Anderson Island	5,032	100,000
McNeil Island	4,217	370,000
Hartstene Island	13,597	100,000
North Fork Skokomish	69,841	100,000
Dosewallips-Duckabush	146,133	100,000
East Hood Canal	53,841	100,000
Total	314,563	$970,000

Recreation

Due to the abundance of surface waters and the wealth of other recreation attractions, the well-planned development of the natural resources within the West Sound Basins would provide many opportunities to satisfy recreation demand.

The West Sound Basins have the most extensive salt water recreation resources of any basin or island area within the Study Area. The central and eastern portions are completely interlaced with sheltered waters which are augmented by attractive islands, bays and fresh water lakes. In the western portion, the beautiful Olympic Mountains rise from the clear waters of Hood Canal. Numerous streams, plus Lake Cushman, provide further attractions within the mountainous reaches. Many people are attracted by the beautiful rhododendrons in the Port Townsend area and along the Quilcene River.

As a desirable planning goal, 20 percent of the water-related recreation demands in the West Sound Basins would be satisfied at lakes and reservoirs, 15 percent at rivers and streams, 10 percent at swimming pools, and 55 percent on salt water oriented areas. This allocation of demand is based upon existing water and associated land resources.

Based upon Federal land ownership, plans and programs of recreation suppliers, expected population concentrations, as well as outdoor recreation needs, supports an assumption that Federal agencies could provide 10 percent of the required water-related opportunities while the State, county and local agencies, and private interests could supply 35, 30 and 25 percent, respectively.

The recreation development contained in the Comprehensive Plan is intended to be compatible with the Washington State-wide Outdoor Recreation and Open Space Plan.

Additional facilities and acquisition and development of land and water areas are required to satisfy the demand for water-related outdoor recreation. The specific land and water area needs are:

Recreation Land and Water Requirements
1960-2020

Activity	Unit	1960 Land	1960 Water	1980 Land	1980 Water	2000 Land	2000 Water	2020 Land	2020 Water
Swimming									
Beach area	Acres	0	0	0	0	52	7	172	25
Pools	Sq. Ft.	*35,800*	*17,900*	*88,800*	*44,100*	*190,800*	*95,900*	*390,800*	*186,900*
Boating, sailing and water skiing	Acres	53	0	213	0	528	0	1,103	102,621
Camping	Acres	275	0	965	0	2,265	0	4,565	0
Picnicking	Acres	191	0	451	0	851	0	1,751	0
Hiking	Miles	0	0	126	0	386	0	786	0

The recreation development contained in the Comprehensive Plan for the West Sound Basins is discussed as follows:

1970-1980—Improvement and further development of recreation facilities at the 149 publicly-administered outdoor recreation areas within the Basin, along with development of new areas on existing publicly-administered land is planned for this period. Access and improvement to the numerous State shorelines on Puget Sound, Hood Canal and the many rivers is also included. A designation of a network of scenic roads to provide travel links between recreation attractions, which would enhance both driving for pleasure and sightseeing opportunities is contained in the Plan. Where practical, hiking and riding tracts should also be developed within the corridor of scenic roads. Facilities to accommodate the small boating demand in the Basins are scheduled for construction. Care must be exercised to insure that the recreation developments are not detrimental to the quality of both fresh and marine waters.

Approximately 100 recreation areas would be expanded or developed during this period. Scenic access easements should be acquired along the rivers and streams throughout the Basin to insure greenbelts are provided.

A State system is suggested to retain important

recreation rivers or river segments in their natural free-flowing state. A study is recommended for the Skokomish River and its North and South Forks, Hamma Hamma River, Duckabush River, Dosewallips River and the Big Quilcene River. Investments for recreation facilities are tabulated below for the various water-related improvements.

Outdoor Recreation Improvements
1970-1980

Feature	Investment Costs ($1000)	Average Annual Costs: Interest & Amortization ($1000)	Average Annual Costs: Operation & Maintenance ($1000)	Average Annual Costs: Total ($1000)	Average Annual Benefits ($1000)
Campground	13,510				
Picnic area	1,477				
Trails	756				
Swimming pools	1,123				
Boating facilities	18,003				
Planning and design	8,717				
Land acquisition	18,626				
Total	$62,212	$4,240	$1,165	$5,405	$6,000

1980-2000—During this period, more extensive development of public lands is anticipated, although acquisition of private lands would be required to fulfill the demand. Need for all types of recreational development, including small boat basins, would continue during this period. Total recreation development costs during this period are estimated at $82,100,000, including land acquisition estimated at $27,100,000, including buffer zones. About 90 recreation areas are planned for expansion or new development.

2000-2020—More extensive development of public land is anticipated, although acquisition of private lands would be required to fulfill the demand. Need for all types of recreational development, including small boat basins, would continue. Total recreation development costs during this period are estimated at $133,700,000, including land acquisition with buffer zones estimated at $50,700,000. Approximately 70 recreation areas would be expanded or developed during this latter period.

Fish and Wildlife

The West Sound Basins offer numerous opportunities for projects and programs that, if implemented, would maintain and enhance wildlife populations, and increase fish and shellfish production. That portion of the Comprehensive Plan dealing with fishing and hunting opportunities is discussed as follows:

1970-1980—Measures to fulfill fish needs in the early action period include construction of hatcheries for both salmon and trout, expansion of two salmon hatcheries and construction of fish passage facilities over natural barriers on the Hamma Hamma River and Kennedy Creek. Also included are steelhead and cutthroat rearing ponds, acquisition and development of 13 access areas to lakes within the Basin, enlargement of Bay Lake, acquisition and development of salt water access for both fishermen and hunters, acquisition and development of 100 miles of stream access and clear stream channels and lakes.

Measures for the enhancement of wildlife comprise improvement of habitat for big game animals, increase capacity of bird farm by 5,000 birds, acquisition and development of estuarine waterfowl environment on 1,400 acres, elk winter range, and upland game habitat.

Programs would be implemented to benefit both hunters and fishermen. These programs include

the development of new fish toxicants, fish disease control and lake fertilization techniques. Those programs associated with game animals include cooperative programs with private land owners to preserve habitat and insure hunter success, development of educational programs to stress renewable aspects and proper harvest of wildlife, and new methods for wildlife population analysis habitat improvement techniques, and compatible forest-wildlife practices. Projects and programs followed by costs included in the Comprehensive Plan for fish and wildlife are:

Fish and Wildlife
Projects and Programs
1970-1980

Projects

a. Construct fish passage facilities on Hamma Hamma River and Kennedy Creek.
b. Clear stream channels and lakes.
c. Construct new Hood Canal salmon hatchery.
d. Develop steelhead and cutthroat rearing ponds.
e. Construct trout hatcheries.
f. Enlarge Bay Lake.
g. Increase capacity of game farm by 5,000 birds.
h. Improve big game habitat.
i. Acquire and develop access to 13 lakes.
j. Acquire and develop 10 saltwater access areas.
k. Acquire and develop 100 miles of stream access.
l. Acquire and develop estuarine waterfowl environment—1,400 acres.
m. Acquire and develop upland game habitat.
n. Acquire and develop elk habitat.
o. Enlarge George Adams salmon hatchery.
p. Enlarge Hood Canal salmon hatchery.

Programs

a. Perform cross-sectional studies of streams for optimum and minimum low flow determination.
b. Locate, survey and mark boundaries of all State-owned second class tidelands. Take steps to reserve all such lands for public use except as required by specific circumstances.
c. Develop lake and stream fertilization techniques.
d. Develop new fish toxicants.
e. Develop a cooperative program with land owners to maintain habitat and allow access.
f. Develop an educational program to stress habitat utilization and retention for the wildlife resource.
g. Develop compatible forest-wildlife management practices and conduct wildlife population analyses.

Fish and Wildlife
Project and Program Costs
1970-1980

Feature	Investment Costs ($1000)	Average Annual Costs: Interest & Amortization ($1000)	Average Annual Costs: Operation & Maintenance ($1000)	Average Annual Costs: Total ($1000)	Average Annual Benefits ($1000)
Projects	6,284	294	289	583	1,571
Program	465[1]				430
Total	$6,749	$294	$289	$583	$2,001

[1] Cumulative program costs for the period.

1980-2000—Habitat improvements are planned for salmon, including fish passage facilities on six streams to provide an additional 52 miles of stream habitat, improvement of habitat on 19 streams resulting in 31 additional stream miles, clearing channels on eight streams providing 14 stream miles, construction of four salmon hatcheries, 3 miles of spawning channel and 40 acres of rearing ponds. Additional game fish and wildlife projects would be continued during this period. The program initiated prior to 1980 would also be continued in this period.

Fish and Wildlife
Projects and Programs
1980-2000

Project	Investment Costs
Fish passage on 6 streams	164,000
Improve habitat—19 streams	128,000
Clear channels—8 streams	3,000
Construct four salmon hatcheries	4,080,000
Construct 40-acre rearing ponds	220,000
Construct 3 miles spawning channels	2,100,000
Game fish and wildlife projects	6,694,000
Total	$13,389,000

Programs	
Continue established programs and initiate new programs	$ 800,000

2000-2020—Projects to benefit migratory fish include construction of five hatcheries, development of 150 acres of rearing facilities and development of 1 mile of spawning channel. Additional game fish and wildlife projects would also be undertaken in this time period. Programs initiated before the year 2000 would be continued and new ones developed.

Fish and Wildlife
Projects and Programs
2000-2020

Project	Investment Costs
Construct 5 hatcheries	5,100,000
Develop 150-acre rearing facilities	825,000
Develop 1 mile spawning channel	700,000
Game fish and wildlife projects	8,229,000
Total	$14,854,000

Programs	
Continue established programs and initiate new programs	$ 800,000

COST-BENEFIT SUMMARY

The investment costs by resource feature are shown in Tables 11-19 and 11-20 for the West Sound Basins, with the costs distributed between Federal, State, local and private interests. Average annual costs and benefits are also shown for projects recommended for implementation prior to 1980. The investment costs include cumulative annual program costs for each of the three planning periods as shown in Table 11-19, and capital project costs as shown in Table 11-20. Interest and amortization costs are based on a 100-year economic life with appropriate allowances made for major replacements. An interest rate of 4-5/8 percent was used in the economic analysis. All measures proposed for early action are justified on the basis of tangible benefits. Benefits for municipal and industrial water supply and water quality improvement were assumed to be equal to annual charges.

Investment costs were allocated to the various interests on the basis of available information including the technical appendices, multiple-purpose project studies, and experience at similar projects.

TABLE 11-19. Program investment costs,[1] West Sound Basins ($1000)

Feature	Private	Government			Total
		Local	State	Federal	
			1970-1980		
Water Quality Control	95	95	380	180	750
Flood Control		87	25	13	125
Watershed Management	45,563	23,590	8,282	19,969	97,404
Fish and Wildlife			465		465
Subtotal	$ 45,658	$23,772	$ 9,152	$20,162	$ 98,744
			1980-2000		
Water Quality Control	60	60	168	72	360
Flood Control		70	20	10	100
Watershed Management	53,392	22,634	11,042	34,634	121,702
Fish and Wildlife			800		800
Subtotal	$ 53,452	$22,764	$12,030	$34,716	$122,962
			2000-2020		
Water Quality Control	80	80	224	96	480
Flood Control		70	20	10	100
Watershed Management	49,774	22,526	11,042	37,274	120,616
Fish and Wildlife			800		800
Subtotal	$ 49,854	$22,676	$12,086	$37,380	$121,996
Total	$148,964	$69,212	$33,268	$92,258	$343,702

[1] Cumulative annual program costs over the period.

TABLE 11-20. Project investment costs[1] and cost-benefit summary, West Sound Basins ($1000)

Feature	Investment Costs					Annual Costs			Annual Benefits	
		Government								
	Private	Local	State	Federal	Total	Interest & Amortization[2]	Operation & Maintenance	Total	Total	Net
			1970-1980							
M&I Water Supply	2,190	6,130	0	0	8,320	465	502	967	967	0
Irrigation	50	0	0	0	50	3	4	7	7	0
Water Quality Control	2,300	3,700	1,850	3,050	10,900	557	119	676	676	0
Navigation[3]	0	0	0	0	0	0	0	0	0	0
Flood Control	0	15	0	135	150	7	4	11	12	1
Watershed Management[4]	0	343	0	736	1,079	50	9	59	150	91
Recreation	15,553	18,664	21,774	6,221	62,212	4,240	1,165	5,405	6,000	595
Fish and Wildlife	0	0	6,284	0	6,284	294	289	583	1,571	985
Subtotal	$20,093	$ 28,852	$ 29,908	$10,142	$ 88,995	$5,616	$2,092	$7,708	$9,323	$1,615
			1980-2000							
M&I Water Supply	1,280	16,910	0	0	18,190					
Irrigation	70	0	0	0	70					
Water Quality Control	4,400	8,300	4,150	8,450	25,300					
Navigation[3]	0	0	0	0	0					
Flood Control	0	114	0	1,026	1,140					
Watershed Management[4]	0	2,416	0	5,639	8,055					
Recreation	20,525	24,630	28,735	8,210	82,100					
Fish and Wildlife	0	0	13,389	0	13,389					
Subtotal	$26,275	$ 52,370	$ 46,274	$23,325	$148,244					
			2000-2020							
M&I Water Supply	0	5,360	0	0	5,360					
Irrigation	70	0	0	0	70					
Water Quality Control	8,000	12,250	6,125	10,925	37,300					
Navigation[3]	0	0	0	0	0					
Flood Control	0	0	0	0	0					
Watershed Management[4]	0	291	0	679	970					
Recreation	33,425	40,110	46,795	13,370	133,700					
Fish and Wildlife	0	0	14,854	0	14,854					
Subtotal	$41,495	$ 58,011	$ 67,774	$24,974	$192,254					
Total	$87,863	$139,233	$143,956	$58,441	$429,493					

1 Capital project costs.

2 Of initial investment and major replacement.

3 Costs and benefits for pleasure boating moorage facilities included with Recreation.

4 Investment for structural measures installation only.

SEQUENCE OF DEVELOPMENT

The projects and programs are summarized in Table 11-21 by time periods. The project numbers identify features on the Basin maps (Figure 11-3).

TABLE 11-21. Future projects and programs, West Sound Basins

PROJECTS PRIOR TO 1980

Municipal and Industrial Water Supply

1. Expansion and updating of existing sources and systems to supply Shelton, Bremerton, Port Orchard, Gig Harbor and Port Townsend.
2. Development of contiguous ground water systems to supply Bainbridge Island and the northern Kitsap Peninsula.

Irrigation

3.* Construction of individual farm irrigation pumping and sprinkler systems (private).

Water Quality Control

4. Construction of treatment and outfall facilities at Port Townsend, Fort Warden and industrial water at Port Townsend.
5. Interception to Bremerton of industrial shipboard wastes from naval shipyard.
6. Modification of log storage practices in Shelton Harbor.
7.* Systematic waste collection, treatment and discharge for newly developed areas including small boat harbors.

Navigation

8. Small boat harbor development—Port Discovery.
9. Small boat harbor development—Sequim Bay.
10. Small boat harbor development—Sinclair Inlet.
11. Small boat harbor development—Mats Mats Bay.
12. Small boat harbor development—Brownsville.
13. Small boat harbor development—Dyes Inlet.

Flood Control

14. Construct levee on the right bank of the Dosewallips River.

Watershed Management

15. Small watershed multiple-purpose project—Chimacum Creek.
16. Small watershed multiple-purpose project—Goldsborough Creek.

Recreation

17. Enlargement or new development of two recreation sites.
18. Enlargement or new development of one recreation site.
19. Enlargement or new development of six recreation sites.
20. Enlargement or new development of three recreation sites.
21. Enlargement or new development of two recreation sites.
22. Enlargement or new development of one recreation site.
23. Enlargement or new development of 15 recreation sites in Olympia National Forest and Park.

Fish and Wildlife

24. Construction of fish passage facilities over barriers on the Hamma Hamma River and Kennedy Creek.
25. Enlarge Bay Lake.
26.* Construct new Hood Canal salmon hatchery.
27.* Construct new trout hatcheries.
28. Enlarge George Adams salmon hatchery.
29. Enlarge Hood Canal salmon hatchery.
30.* Increase capacity of game farm by 5,000 pheasants.
31.* Develop steelhead and searun cutthroat rearing ponds.
32.* Clear stream channel and lakes.
33.* Improve big game habitat.
34.* Acquire and develop access to 13 lakes.
35.* Acquire and develop 10 saltwater access areas.
36.* Acquire and develop 100 miles of streambank access.
37.* Acquire and develop estuarine waterfowl environment—1,400 acres.
38.* Acquire and develop upland game habitat.
39.* Acquire and develop elk habitat.

PROGRAMS PRIOR TO 1980

Water Quality Control

a. Establish and maintain water quality surveillance stations and prepare comprehensive sewerage plan for Basins.

*Projects not shown on Figure 11-3

TABLE 11-21. Future projects and programs, West Sound Basins (Cont'd)

Flood Control

b. Establish and maintain flood plain zoning on the Skokomish, Hamma Hamma, Duckabush, Dosewallips, Big Quilcene and Little Quilcene Rivers.

Watershed Management

c. Provide technical assistance and management for State and Federal lands.
d. Provide technical assistance for on-farm and other private practices.

Fish and Wildlife

e. Conduct cross-sectional measurements to determine minimum streamflows to maintain existing levels of fish production.
f. Locate, survey and mark boundaries of all State-owned second class tidelands. Take steps to reserve all such lands for public use except as required by specific circumstances.
g. Develop lake and stream fertilization techniques.
h. Develop new fish toxicants.
i. Develop a cooperative program with land owners to maintain wildlife habitat and allow hunter access.
j. Develop an educational program to stress habitat utilization and retention for the wildlife resource.
k. Develop compatible forest-wildlife management practices and conduct wildlife population analyses.

PROJECTS 1980-2000

Municipal and Industrial Water Supply

40. Construct facilities to develop a regional water system for the Bremerton area in the Duckabush River.
41.* Expansion of existing water supply systems at Shelton, Port Orchard, Gig Harbor, Port Townsend, Bainbridge Island, Vashon Island, Pouslbo and rural system and self-supplied industrial.

Irrigation

42.* Construction of individual farm irrigation pumping and sprinkler systems (private).

Water Quality Control

43.* Expansion of existing waste treatment facilities.
44.* Construction of new waste collection and treatment facilities to accommodate newly locating developments.
45.* Provide for collection and treatment of pleasure boating related wastes.

Navigation

46. Small boat harbor development–Port Townsend.
47. Small boat harbor development–Oak Bay.
48. Small boat harbor development–Hoodsport.
49. Small boat harbor development–Manchester.
50. Small boat harbor development–Bainbridge Island–Murden Cove.
51. Small boat harbor development–Bainbridge Island–Lynwood Center.
52. Small boat harbor development–Hood Canal–Coon Bay.
53. Small boat harbor development–Hood Canal–Duckabush.
54. Small boat harbor development–Hood Canal–Union.

Flood Control

55. Construct 6,000-foot levee, right bank, Big Quilcene River.
56. Construct levee on Skokomish River.

Watershed Management

57. Small watershed multiple-purpose project–Skookum Creek.
58. Small watershed multiple-purpose project–Northwest Shelton.
59. Small watershed multiple-purpose project–South Fork Skokomish.
60. Small watershed multiple-purpose project–North Hood Canal.
61. Small watershed multiple-purpose project–Carr Inlet.
62. Small watershed multiple-purpose project–Vashon Island.
63. Small watershed multiple-purpose project–West Kitsap area.
64. Small watershed multiple-purpose project–East Kitsap area.
65. Small watershed multiple-purpose project–Quilcene.
66. Small watershed multiple-purpose project–East Jefferson.
67. Small watershed multiple-purpose project–Sequim Bay.
68. Small watershed multiple-purpose project–Johnson Creek.

Recreation

69. Enlargement or development of two recreation sites.
70. Enlargement or development of four recreation sites–Discovery Bay.
71. Enlargement or development of one recreation site–Indian Island.
72. Enlargement or development of four recreation sites.
73. Enlargement or development of 13 recreation sites–Hood Canal.

*Projects not shown on Figure 11-3

TABLE 11-21. Future projects and programs, West Sound Basins (Cont'd)

74. Enlargement or development of 23 recreation sites—Kitsap Peninsula.
75. Enlargement or development of four recreation sites.
76. Enlargement or development of two recreation sites.
77. Enlargement or development of 18 recreation sites—Southern Puget Sound.
78. Enlargement or development of 15 recreation sites—Olympia National Forest and Park.

Fish and Wildlife

79.* Conduct habitat improvement on 19 streams for 31 miles.
80.* Provide channel clearance on eight streams for 14 miles.
81.* Improve fish passage on six streams for 52 miles.
82.* Construct four hatcheries, 40 acres of rearing ponds and 3 miles of spawning channel.

PROGRAMS 1980-2000

Water Quality Control

l. Continue monitoring, evaluation and control programs.

Flood Control

m. Continue flood plain zoning program.

Watershed Management

n. Provide technical assistance and management for State and Federal lands.
o. Provide technical assistance for on-farm and other private practices.

Fish and Wildlife

p. Continue management and educational programs initiated in the early action period.

PROJECTS 2000-2020

Municipal and Industrial Water Supply

83.* Expansion of systems to meet demands.

Irrigation

84.* Construction of individual farm irrigation pumping and sprinkler systems (private).

Water Quality Control

85.* Expansion of existing waste collection and treatment facilities.
86.* Construction of new waste collection and treatment facilities to accommodate newly locating and expanding development.
87.* Provide for collection and treatment of pleasure boating related wastes.

Navigation

88. Small boat harbor development—Kingston.
89. Small boat harbor development—Quilcene Bay—East Side.
90. Small boat harbor development—Bainbridge Island—Fletcher Bay.
91. Small boat harbor development—Marrowstone Island—East Side.
92. Small boat harbor development—Hood Canal—Bywater Bay.
93. Small boat harbor development—Hood Canal—Thorndyke Bay.
94. Small boat harbor development—Hood Canal—Warrenville.
95. Small boat harbor development—Hood Canal—Anderson Cove.

Watershed Management

96. Small watershed multiple-purpose project—Isabella.
97. Small watershed multiple-purpose project—Anderson Island.
98. Small watershed multiple-purpose project—McNeil Island.
99. Small watershed multiple-purpose project—Hartstene Island.
100. Small watershed multiple-purpose project—North Fork Skokomish.
101. Small watershed multiple-purpose project—Dosewallips-Duckabush.
102. Small watershed multiple-purpose project—East Hood Canal.

Recreation

103. Enlargement or development of one recreation site.
104. Enlargement or development of five recreation sites—Discovery Bay.
105. Enlargement or development of one recreation site—Indian Island.
106. Enlargement or development of four recreation sites—Port Ludlow.
107. Enlargement or development of 15 recreation sites—Hood Canal.

*Projects not shown on Figure 11-3

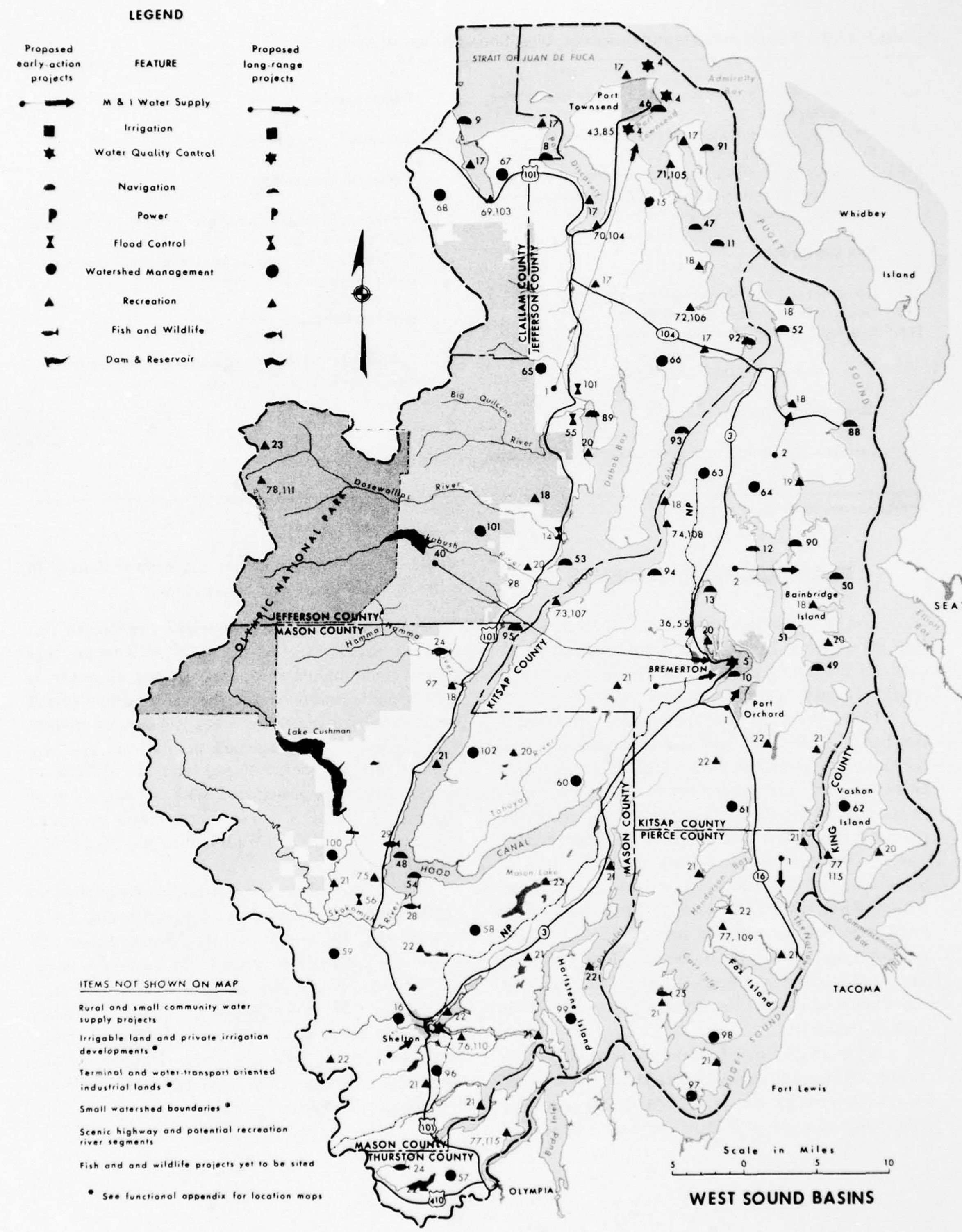


FIGURE 11-3. Comprehensive Plan elements

TABLE 11-21. Future projects and programs, West Sound Basins (Cont'd)

108. Enlargement or development of 11 recreation sites—Kitsap Peninsula.
109. Enlargement or development of four recreation sites—Southern Puget Sound.
110. Enlargement or development of two recreation sites.
111. Enlargement or development of 20 recreation sites—Olympia National Forest and Park.

Fish and Wildlife

112.* Construct five hatchery equivalent stations.
113.* Develop 150 acres of rearing facilities.
114.* Develop 1 mile of spawning channel.

PROGRAMS 2000-2020

Water Quality Control

q. Continue monitoring, evaluation and control programs.

Flood Control

r. Continue flood plain zoning.

Watershed Management

s. Provide technical assistance and management for State and Federal lands.
t. Provide technical assistance for on-farm and other private practices.

Fish and Wildlife

u. Continue management and educational programs initiated in the early action period.

*Projects not shown on Figure 11-3

PLAN ACCOMPLISHMENTS

The accomplishments of the Comprehensive Plan are shown in Table 11-22. All of the quantifiable needs of the Basins would be met by the Plan except for flood control and pleasure boat moorages.

Flood plain management program instituted in the Basins to regulate land use commensurate with the degree of flood risk would limit future damages. However, land use requirements of the expanding population is expected to become critical enough to economically justify construction of flood control levees. The only levee system currently justified would protect Dosewallips State Park on the Dosewallips River. In the Skokomish River Basin, after 1980, a levee system would provide 25-year protection for 3,000 acres of the 4,600-acre flood plain. For the Big Quilcene River Basin a levee system would be constructed to protect the urban development in the town of Quilcene.

All watershed management needs would be met except urban water management. These needs would be entirely met by the year 2020. In the preceding time periods a residual is shown as intensive land use would be required to achieve a minimum density in order to facilitate project undertaking.

All of the fisherman-day and commercial fish needs would be satisfied by the Plan assuming that present pollution problems are corrected. However, as only specific solutions for the early action period were provided for wildlife needs, subsequent periods were assumed to be satisfied by projects and programs that would be developed later. A reduction in hunter success is anticipated with a willingness of hunters to accept a lower success ratio or utilize hunting areas in Eastern Washington, in order to fully meet the needs.

Recreation needs are assumed to be satisfied by including all the projects and programs called for in Appendix X, Recreation, the West Sound Basins. All of the rivers considered suitable for recreation status in Appendix X are left in their free-flowing state throughout their entire lengths except for the Duckabush River where a storage project is planned. Levee improvements on the Skokomish, Dosewallips and Big Quilcene Rivers would not be detrimental to the recreation status of the rivers.

TABLE 11-22. Comprehensive Plan accomplishments, West Sound Basins

Feature	Units	1980 Needs	1980 Accomp.	1980 Residual	2000 Needs	2000 Accomp.	2000 Residual	2020 Needs	2020 Accomp.	2020 Residual
M&I Water Supply	mgd	43.8	43.8	0	89.8	89.8	0	132.2	132.8	0
	(1000 Acre-Feet)	48.1	48.1	0	99.7	99.7	0	147.8	147.8	0
Irrigation	1000 Acre-Feet	1.0	1.0	0	2.3	2.3	0	3.5	3.5	0
Water Quality Control										
Waste	1000 Population Equivalents	542	542	0	929	929	0	1,306	1,306	0
Navigation										
Commercial	1000 Short Tons	0	0	0	0	0	0	0	0	0
Pleasure Boats	Wet Moorages	8,600	4,310	4,290	17,280	17,310	30	30,580	30,530	50
Power[1]										
Flood Control	$1000 Damage Reduction	68	16	52	100	74	26	158	120	38
Watershed Management										
Flood Prevention	1000 Acres	44.5	44.5	0	44.5	44.5	0	44.5	44.5	0
Watershed Protection and Rehabilitation[2]	1000 Acres	1,281.4	1,281.4	0	1,281.4	1,281.4	0	1,281.4	1,281.4	0
Water Management[3]										
Agricultural	1000 Acres	17.1	17.1	0	28.6	28.6	0	38.1	38.1	0
Urban	1000 Acres	106.4	35.5	70.9	106.4	72.6	33.8	106.4	106.4	0
Recreation	1000 User-Days	5,100	5,100	0	12,700	12,700	0	26,200	26,200	0
Fish and Wildlife										
Sport										
Fishing	1000 User-Days	424	424	0	1,064	1,064	0	2,097	2,097	0
Hunting	1000 User-Days	120	120	0	274	274	0	368	368	0
Commercial Fishing	1000 Pounds	278	278	0	5,169	5,169	0	8,869	8,869	0

1 Power needs projected for the Puget Sound Area only.

2 The necessary level of management is assumed to be established throughout the Basins, otherwise some residual could occur.

3 Needs and accomplishments are cumulative.

ALTERNATIVE ELEMENTS

Alternative measures considered to those elements contained in the Comprehensive Plan and the reasons for not adopting these alternatives are discussed in this section.

Alternatives to Flood Control Elements

In the Skokomish River Basin the only other measures which could reduce flood damages are storage projects upstream of the flood plain. Construction of storage projects could provide 100-year protection thereby encouraging residential and recreation-type developments on the flood plain. Relying on flood plain management would not satisfy the need for enhanced agricultural production through a reduction of reoccurring flood damages.

On the Dosewallips River, upstream storage could control flooding. However, the costs of such a project far exceed the benefits. The flood storage project also might have detrimental effects on the natural environment of the river basin. Flood plain management would not solve the flood problem at the existing State park, but could limit future damages due to growth in the flood plain.

In the Big Quilcene, upstream sites are available to contain flood flows, but the costs exceed the expected benefits. Flood plain management could limit the future damages in the community of Quilcene, but the community would still be exposed to flooding. Floodproofing of the existing structures in the Quilcene is not economically feasible due to the type of existing construction.

Alternatives to Duckabush Storage Project

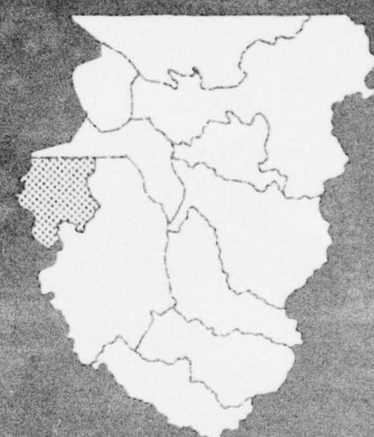
Supplying water to Bremerton and the surrounding vicinity would require expansion of the existing surface water source. Ground water sources in the vicinity are not expected to be adequate to meet the projected demands. Alternative sources are other streams on the Olympic Peninsula with the Hamma Hamma being the most probable. The flows in the Hamma Hamma are less than the Duckabush and development costs for an assured flow would be approximately equal. Using the stream with the small flow was considered less desirable from environmental and fisheries standpoints.

Other alternatives considered for meeting the water supply needs included desalinization and interbasin transfer. Neither of these alternatives are economically feasible.

Alternatives to Recreation and Fish and Wildlife Measures

As limited information was provided with regard to specific locations of recreation developments, no analysis could be made to determine if sites and proposed developments were necessarily the most economical or compatible with the natural environment. All fish and wildlife measures contained in Appendix XI, Fish and Wildlife, were included in the Comprehensive Plan with the exception of flood control and flow augmentation on various streams. In lieu of these latter two measures, artificial fish propagation facilities and fish passage over a natural barrier have been included. These measures are expected to provide equivalent benefits to the fishery. Completion of the cross-sectional study surveys by 1980 would provide data from which further studies of projects can be undertaken to determine if impoundments can be justified on a multiple-purpose basis.

Elwha-Dungeness Basins



ELWHA—DUNGENESS BASINS

DESCRIPTION OF BASINS

GENERAL

The Elwha-Dungeness Basins encompass 688 square miles of land, and 2 square miles of inland fresh water. There are 107 square miles of marine waters with 56 miles of shoreline included within the boundaries of the Basins. The major streams of the Basins are the Elwha and the Dungeness Rivers which drain into the Strait of Juan de Fuca. The Elwha Basin drains 321 square miles, the Dungeness Basin drains 198 square miles, and coastal streams drain 170 square miles of foothills and coastal plains. The mean annual runoff for the Elwha River near McDonald Bridge is 1,095,000 acre-feet, and the Dungeness River near Sequim is 277,000 acre-feet. Ground water acquifers are recharged in the lowland plains by natural precipitation and runoff from the mountains. The amount of ground water recharge is estimated at 10,000 acre-feet annually. Probably no more than one-half of this recharge can be intercepted by wells as the hydraulic gradients exceed 100 feet per mile. Irrigation is an important secondary source of ground water recharges in the Sequim-Dungeness area.

The Basins lie in the rain shadow of the Olympic Mountains resulting in a marked decrease of precipitation from an estimated 200 inches annually at the headwaters of the Elwha River to 24 inches at its mouth. Annual precipitation on the plain near the mouth of the Dungeness River is about 16 inches thereby causing a distinct semi-arid climate on the lowlands. About 30 percent of the lowlands precipitation occurs between April and September. A fairly high incidence of sunshine, absence of destructive winds and a 195 day growing season make the Basin favorable for agriculture, recreation and suburban development.

Streamflow characteristics and other related hydrologic data are discussed in detail in Appendix III, Hydrology and Natural Environment. The physiographic characteristics are discussed in more detail in Appendix V, Water-Related Land Resources.

PRESENT SITUATION

Local Economy

The total population of the Basins was 28,500 in 1967 and the cities and towns accounted for 17,200 or 70 percent of the population (Table 12-1).

TABLE 12-1. Historical population, Elwha-Dungeness Basins

	1940	1950	1960	1967
Elwha-Dungeness Basins	16,200	19,500	22,200	28,500
Principal cities and towns:				
Port Angeles	9,400	11,200	12,600	15,800
Sequim	600	1,000	1,200	1,500

Source: Appendix IV, Economic Environment, Appendix V, Water-Related Land Resources.

The economy is based primarily upon timber, wood products, agriculture, and tourism. Paper production provides employment for about 500 people and an additional 200 people are employed in logging operations in support of the industry. The principal products of the timber industry are lumber; plywood, newsprint, pulp, fiberboard, shakes and shingles.

Port Angeles is the first port of entry for ships coming into Puget Sound. Log exports provide a large part of shipping from the harbor. The town of Sequim is the trade center for the agricultural area and the settlements of Dungeness, Agnew, Blyn, Carlsborg and Jamestown, an Indian village.

Tourism is a rapidly growing industry due to the Basins' wealth of scenic and recreation assets. Olympic National Park is a big attraction for recreationists. Many motorists pass through on U.S. Highway 101 on their way around the Olympic Peninsula. Still, many others use Port Angeles as an embarkation point, by ferry, to Victoria, B.C. Thus, numerous business establishments have been developed to furnish services or sell directly to the tourist consumer.

Land Use

Within the Basins the land area is 446,600 acres and the fresh water area is 1,800 acres making a total of 448,400 acres of land and fresh water. A tabulation of 1967 land use categories indicate forest and cropland account for 92 percent and 5 percent of the area, respectively, while intensive (built-up), rural nonfarm and rangelands each account for one percent of the area. The distribution of land use by Basin is tabulated in Table 12-2 and is shown on Figure 12-1.

TABLE 12-2. Present land use, Elwha-Dungeness Basins

Land Use	Acres	Percent
Forest	409,500	91.8
Cropland	23,700	5.2
Rangeland	2,400	0.5
Rural nonfarm	5,100	1.1
Intensive (built-up)	5,900	1.3
Total	446,600	100.0

Source: Appendix V, Water-Related Land Resources.

The intensive, urban and built-up land use categories consist of residential areas, industrial, public and semi-public uses and reserved open space. The intensive use tabulated in acres follows: railroads 500; roadways 1,000; airports 500; and urban (built-up) 4,000; for a total of about 6,000 acres (Appendix V, Water-Related Land Resources).

Land ownership is shown in Table 12-3.

TABLE 12-3. Land ownership, Elwha-Dungeness Basins

Ownership	Percent
Private	17.4
Private corporate	0.2
Federal	72.0
State	5.6
Local government	4.8
	100.0

Source: Appendix V, Water-Related Land Resources.

PROJECTED ECONOMY AND LAND USE

Local Economy

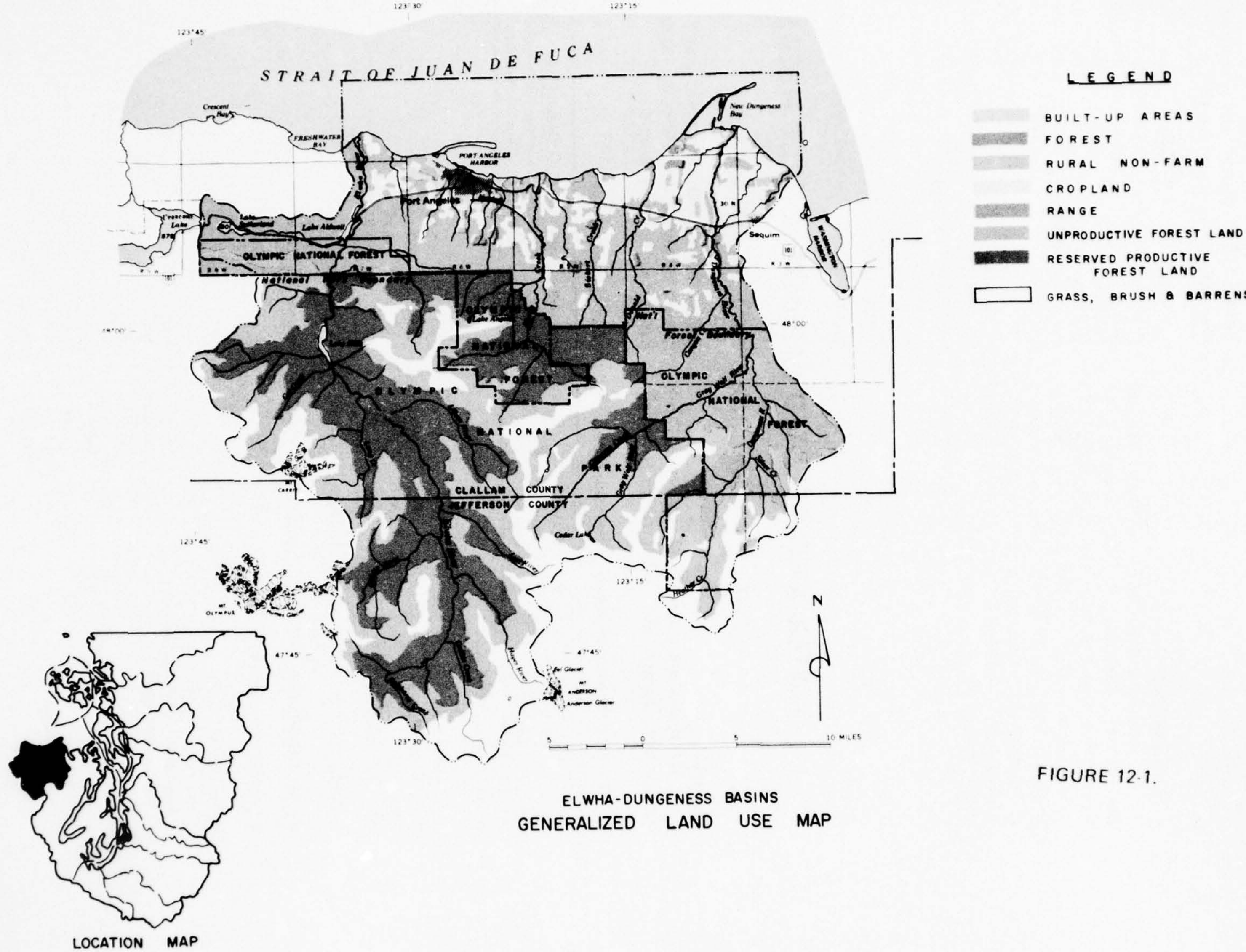
The past economy of the Basins as in the West Division has been oriented toward industries centering around timber and wood products. The projected growth trend of the West Division is shown in Table 12-4.

Major growth strength will be in the pulp and paper products industry, particularly by 1980. While some employment will drop off in the forests, agriculture, lumber, and wood products industry, growth will be experienced in the services, wholesale and trade, construction and government. Growth is expected to be primarily in the recreation, tourist, and retirement home development.

TABLE 12-4. Economic projections, Elwha-Dungeness Basins

					Average Annual Growth Trends (Percent)			
	1963	1980	2000	2020	1963 to 1980	1980 to 2000	2000 to 2020	1963 to 2020
West Division								
Population (1000's)	116.0	122.5	168.5	232.4	0.3	1.7	1.6	1.2
Employment (1000's)	37.7	41.9	57.6	79.5	0.6	1.6	1.6	1.3
Gross Regional Product (1,000,000 $)	290.0	498.0	1,066.0	1,329.0	3.2	3.9	1.1	2.7
Elwha-Dungeness								
Population (1000's)	28.3	29.8	41.0	56.6	0.1	1.5	1.6	1.1

Source: Appendix IV, Economic Environment, Appendix V, Water-Related Land Resources.



ELWHA-DUNGENESS BASINS
GENERALIZED LAND USE MAP

FIGURE 12-1.

Future Land Use

The projected land use for the Basins (Alternative C_2 in Appendix V, Water-Related Land Resources) indicates intensive land use areas by 2020 would displace 2,800 acres of forest, 300 acres of rangeland, 900 acres of rural nonfarm, and 900 acres of cropland and pasture for a total displacement of 4,900 acres. The change of land use is tabulated in Table 12-3 and shown on Figure 12-2.

TABLE 12-5. Present and projected[1] land use, Elwha-Dungeness Basins (acres)[2]

Land Use	1967	1980	2000	2020
Forest	409,500	407,500	407,100	406,700
Rangeland	2,400	2,300	2,200	2,100
Cropland	23,700	23,600	23,200	22,800
Rural nonfarm	5,100	5,000	4,600	4,200
Intensive	5,900	8,200	9,500	10,800
Total	446,600	446,600	446,600	446,600
Population	28,500	29,800	41,000	56,600
Density[3]	3.3	3.6	4.3	5.2

[1] Alternative land use pattern C_2, see Puget Sound Area.

[2] Figures rounded to nearest hundred.

[3] Persons per intensive land use acre.

Source: Appendix V, Water-Related Land Resources.

WATER AND RELATED LAND RESOURCE NEEDS

MUNICIPAL AND INDUSTRIAL WATER SUPPLY

General

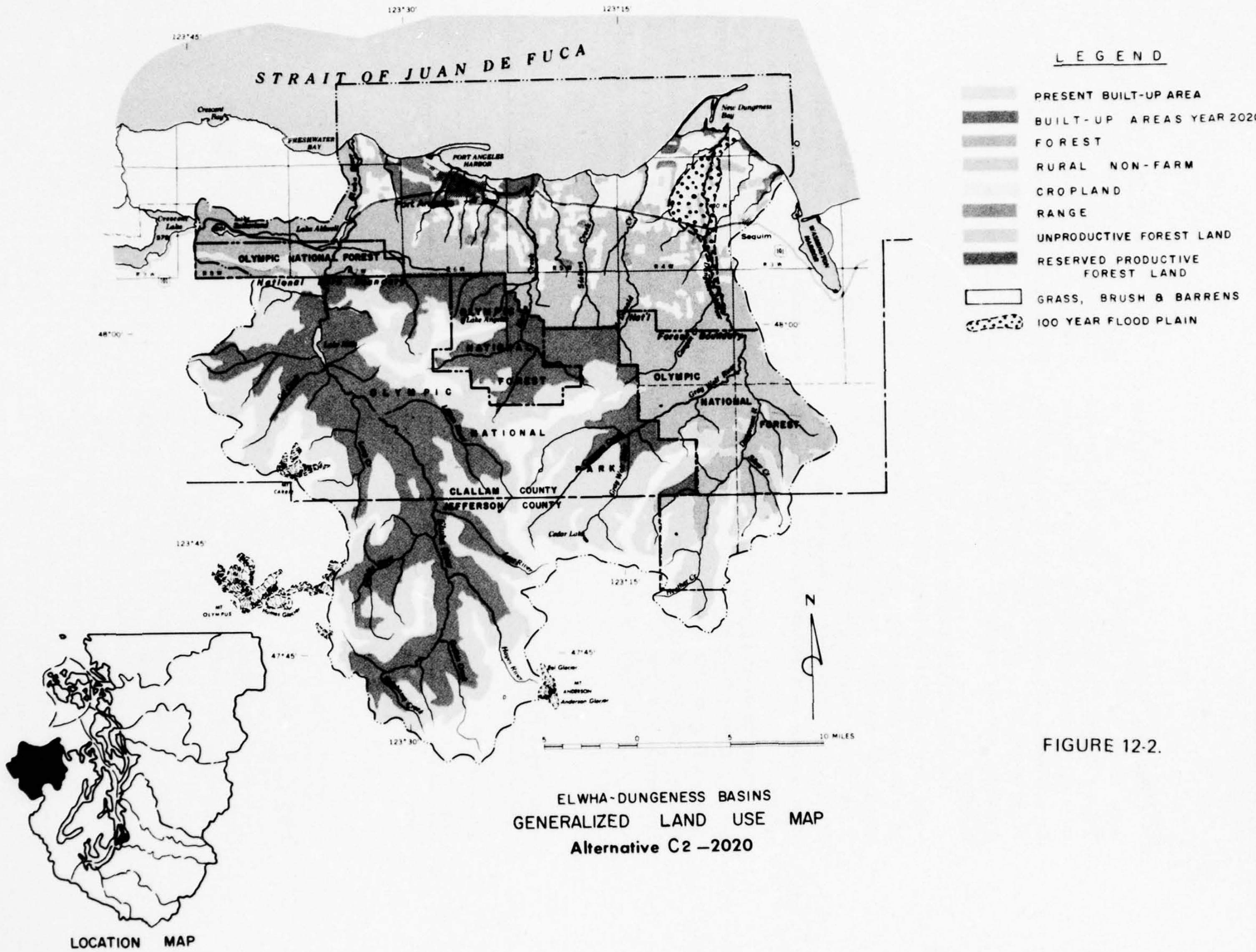
The Elwha and Dungeness Rivers, Morse Creek plus creeks, springs, and wells, currently supply municipalities, individuals, and water associations. Present municipal and industrial water use for the Basins is shown in Table 12-6.

TABLE 12-6. Municipal and industrial water use, 1965, Elwha-Dungeness Basins

		Surface Water Usage (mgd)			Ground Water Usage (mgd)		
System	Estimated Population Served	Average Daily	Maximum Monthly	Maximum Daily	Average Daily	Maximum Monthly	Maximum Daily
MUNICIPAL USE							
Port Angeles	15,700	3.78	7.10	11.00	--	--	--
Hoks Waterwell	560	0.05	0.10	0.14	--	--	--
Sequim	1,400	0.75	1.00	1.50	--	--	--
Rural community systems	340	0.01	0.01	0.01	0.03	0.04	0.06
Subtotal	18,000	4.59	8.21	12.65	0.03	0.04	0.06
RURAL-INDIVIDUAL USE	10,500	0.05[1]	0.07	0.10	0.50[1]	0.70	1.00
INDUSTRIAL WATER USE							
Municipally supplied:							
Port Angeles							
Paper and allied (fibreboard)		0.20	2.10	2.50	--	--	--
(Crown Zellerbach)		0.09	0.10	0.10	--	--	--
(Rayonier)		0.17	0.20	0.20	--	--	--
Self-Supplied:							
Paper and allied		58.70	62.50	66.00	--	--	--
Fibreboard		(5.00)	(5.50)	(6.00)	--	--	--
Crown Zellerbach		(18.00)	(19.00)	(20.00)	--	--	--
Rayonier		(35.70)	(38.00)	(40.00)	--	--	--
Subtotal		59.16	64.90	68.80	--	--	--
Total	28,500	63.80	73.20	81.60	0.50	0.70	1.10

[1] Based on 55 gpcd and 90 percent of rural-individual population served by ground water.

Source: Appendix VI, Municipal and Industrial Water Supply.



ELWHA-DUNGENESS BASINS
GENERALIZED LAND USE MAP
Alternative C2 –2020

FIGURE 12-2.

The only municipal system in the Dungeness River Basin utilizing surface water is the town of Sequim. Sequim has a 1.40 cfs water right diversion from the Dungeness River and obtains its supplies from an infiltration gallery adjacent to the river. The site is owned by the city, is free of nearby sources of pollution, and the supply is chlorinated prior to delivery.

The city of Port Angeles obtains its municipal water supply from Morse Creek. The system consists of a simple diversion dam and supply line which supplies the city with 3.78 million gallons daily, but is capable of supplying a peak demand of 8.1 mgd. The water is disinfected for consumptive usage. Some water is supplied to industry through the municipal system.

Industrial water use centers in the Port Angeles area by three pulp mills and averages nearly 60 million gallons per day. These three mills are supplied with raw water from the Elwha River. The fibreboard mill receives water from the city when their primary source from the industrial source is too turbid for making paper.

The city of Port Angeles constructed the industrial diversion and pipeline delivery facilities in 1929 which diverts water from the Elwha River about 3 miles above its mouth. The 60-inch industrial water line has capacity to furnish 70 million gallons daily to the three pulp industries. This facility is owned by the city but operated and maintained by the industries.

Present and Future Needs

Large water using industrial development is not expected in the Dungeness Basin. Additional municipal water use is projected for the town of Sequim, rural community systems and domestic systems.

Water supplies are currently meeting the needs of industries and municipalities in the Elwha Basin. Significant growth of pulp production is predicted at Port Angeles making this a major factor in projecting water needs. Future municipal and industrial water needs are summarized in Table 12-7.

TABLE 12-7. Projected municipal and industrial water needs, Elwha-Dungeness Basins

Year	Use	Total (Average Daily M.G.D.)	Total (1000's Acre-Feet Annually)	Net Needs[1] (M.G.D.)	Net Needs[1] (1000's Acre-Feet)
1965	Municipal	4.6	5.1		
	Industrial	59.1	66.2		
	Rural-Individual	0.6	0.7		
	Total	64.3	72.0		
1980	Municipal	4.0	4.8		
	Industrial	135.0	151.0		
	Rural-Individual	0.8	0.9		
	Total	139.8	155.7	75.5	83.7
2000	Municipal	6.0	7.6		
	Industrial	202.0	226.0		
	Rural-Individual	1.1	1.2		
	Total	209.1	234.8	144.8	162.8
2020	Municipal	9.8	12.2		
	Industrial	259.0	289.0		
	Rural-Individual	1.6	1.8		
	Total	271.0	303.0	207.0	231.0

[1] Cumulative total above 1965 use.

Turbidity is a problem on Morse Creek. Winter storms cause this stream to become highly turbid during short periods. The diversion to the city must be shut off at times until turbidity drops to acceptable limits. An alternate source of supply should be located for the city's use during the spring periods.

Port Angeles and some other local systems will need to enlarge their water delivery system to meet the State Public Health water supply standards. These standards require that a water supply system should have the capability to supply normal peak demands in addition to fire protection requirements. To meet these standards the delivery capability of the Port Angeles system would have to be increased from 8.1 mgd to 14.7 mgd by 1980, 21.7 mgd by 2000, and 30.8 mgd by 2020. The Morse Creek watershed is expected to be capable of meeting peak demands up to 26 mgd. For 1980 the rural community systems in the Basin should be updated by 0.5 mgd to have a total delivery capability of 0.7 mgd. Also the town of Sequim should increase their delivery capability by 0.4 mgd by that time.

IRRIGATION

General

The Basins contain about 25,000 acres of irrigable land of which 15,900 acres are now irrigated. Nearly all irrigation development has occurred on the Dungeness River alluvial plain. Water is obtained from the Dungeness River, some minor streams and by ground water.

Rights to the use of waters of the Dungeness River and its tributaries were adjudicated in the amount of 579.56 cubic feet per second. All of the rights are for irrigation. Since the mean flow during the irrigation season is approximately equal to present irrigation diversion requirements there could be little if any streamflow left in the river below the point of diversion for any other water uses should the irrigators exercise their adjudicated rights and divert their full amount.

Water is supplied to most of the irrigated lands by diversion of natural flows from the Dungeness River through the facilities of nine organized irrigation groups and a number of individual installations. The open ditch distribution facilities of the many different organizations and individuals have been developed over many years with little reference to an orderly plan of development. Farmers pump from the ditches and apply water to their crops by wild flooding and sprinkler application. The result has been duplication of facilities, excessive water losses, maldistribution of water, and deterioration of many structures to the point where extensive rehabilitation is a necessity.

Present irrigation water use is estimated to be 4.73 acre-feet/acre, nearly twice the diversion requirements of any of the other basins within the Puget Sound. The crop consumptive use is estimated to be 2.60 acre-feet per acre. The large diversion requirement results from conveyance losses estimated to be at 45 percent of the amount diverted.

Present and Future Needs

About 6,100 acres, not now irrigated, are expected to be under irrigation by 1980. Estimated future diversions are as shown in Table 12-8.

TABLE 12-8. Irrigation needs, Elwha-Dungeness Basins

Year	New Irrigation (acres)	Total Irrigation (acres)	Total Annual Diversion (ac. ft.)	Net Needs[1] (ac. ft.)
1965	--	15,900	75,000	--
1980	6,100	22,000	104,100	29,100
2000	--	22,000	104,100	29,100
2020	--	22,000	104,100	29,100

[1] Cumulative diversion above 1965 use.

Source: Appendix VII, Irrigation.

The monthly distribution of the irrigation requirements are:

May	6%	July	29%	September	15%		
June	23%	August	21%	October	6%		
				Total	100%		

Irrigation water requirements greater than present cannot be met from natural streamflow of the Dungeness River. Ground water can be used for supplemental supplies, but is not considered adequate in most areas as a source for a full supply.

WATER QUALITY CONTROL

General

The quality of the surface water in the Basin is excellent. The river and stream waters are soft, low in dissolved solids, and high in dissolved oxygen. The sanitary quality of the streams are excellent with MPN values of coliform bacteria usually less than 100. The Elwha and Dungeness Rivers are generally free from suspended sediment, but are somewhat turbid during the winter months.

The principal area of pollution centers about the Port Angeles Harbor, where the State-Federal water quality standards for coliform, DO, temperature, PH, turbidity, toxic and aesthetics are not being met. Both the city of Port Angeles and industry are dumping partially treated raw sewage and pulp mill wastes into the harbor through 13 different outfalls. Two pulp mills account for about 95 percent of this daily wasteload, discharging oxygen consuming wastes concentrations and sludge forming wastes. These wastes affect the marine water quality along the shorelands as far east as Dungeness Spit.

The present quantities and sources of waste discharge are shown in Table 12-9.

Present and Future Needs

The paper and allied industries are projected to produce 2,645,000 PE accounting for 99 percent of the raw waste produced in the Basin in 1980. The hydraulic characteristics of the Port Angeles Harbor-Dungeness Spit eddy system are not adequate to accept the large volumes of strong pulp and paper processing wastes. The abatement of damage to underwater sea life of the Port Angeles Harbor and adjacent beach areas would require the removal of existing sludge deposits and prevention of future sludge accumulation.

The paramount need is adequate waste collection and treatment. These needs must be met primarily by treatment of the wastes for removal of settleable and volatile dissolved solids, rather than by

TABLE 12-9. Summary of municipal and industrial wastes, Elwha-Dungeness Basins, 1965

Receiving Water	Estimated Population Served	Nonseasonal Untreated Waste PE	Seasonal Untreated Waste PE	Treatment	Nonseasonal Waste Discharge PE	Seasonal Waste Discharge PE
Strait of Juan de Fuca						
Paper and allied (Crown Zellerbach)	--	145,000	--	None	145,000	--
Port Angeles						
Port Angeles	15,300	22,800	--	Primary	15,000	--
Paper and allied (Fiberboard)	--	264,000	--	None	264,000	--
Paper and allied (Rayonier)	--	2,820,000	--	None	2,820,000	--
Lumber/wood (Pen Ply)	--	2,400	--	None	2,400	--
Food and kindred	--	2,500	--	None	2,500	--
U.S. Coast Guard Station	200	200	--	Land	--	--
Morse Creek						
Hart of the Hills	--	100	--	Secondary	20	--
Sequim Bay						
Sequim	1,000	1,250	--	Secondary	250	--
Sequim Bay State Park	--	240	--	Primary	150	--
TOTAL[1]	16,500	3,258,600	--	--	3,257,200	--
Municipal	--	24,600	--	--	23,200	--
Industrial	--	3,234,000	--	--	3,234,000	--

[1] PE's will be reduced for all waste discharges after compliance with the Interstate and proposed Intrastate Quality Standards Implementation and Enforcement Plan—1970-1972.

changes in disposal practices. The present and projected wasteloadings are as shown in Table 12-10.

TABLE 12-10. Present and projected raw wasteloadings, Elwha-Dungeness Basins (1000's PE)

Year	Municipal	Industrial[1]	Recreational	Total[1]	Net Needs[2]
1965	24	3,234	6	3,264	3,263
1980	24	2,649	9	2,682	2,681
2000	36	2,803	18	2,857	2,856
2020	53	2,728	32	2,813	2,812

[1] Decrease in raw wastes due to change in pulp and paper process.

[2] Cumulative raw wasteload requiring treatment above that receiving treatment in 1965.

Source: Appendix XIII, Water Quality Control.

The existing water quality surveillance program for the marine waters should be expanded. Stations should be established in the Straits of Ediz Hook, Pilot Station, the pulp mills, ferry dock, Dungeness Spit, Lower Dungeness River and Morse Creek to regularly measure the water characteristics.

NAVIGATION

General

Port Angeles is the first port of entry in the Puget Sound Area. In 1963, there were about 87 acres in use for terminal facilities, about 15 acres for vessel repair and construction, and about 107 acres were used for other water transport-oriented industries. The only small boat harbor in the Basins is located in Port Angeles Harbor and has 20 wet moorages.

The Basins have a limited potential for industrial and port development in the near future because of lack of adequate railroad, highway, and power facilities. However, due to its location as the first port of entry for ships coming into Puget Sound and its forest products oriented industry, development of additional port facilities would be required.

Present and Future Needs

In arriving at the future needs for the Port Angeles Harbor, the terminal facilities and water oriented industries were first determined for the entire Puget Sound Area. In the context of the whole Area, the navigation needs for each basin then were determined.

Due to the recreational character and opportunity of the Basins, salt water boating is expected to increase tremendously. Small boat harbors and facilities are needed now and this need would become more acute in the near future.

The projected tonnages and wet moorage needs for the Basins are shown in Table 12-11.

TABLE 12-11. Projected pleasure boating needs and waterborne commerce, Elwha-Dungeness Basins

	Small Boat Wet Moorages			Waterborne Commerce (1000's Short Tons)	
Year	Total	Net Needs[1]	Year	Total	Net Needs[2]
1966	980	960	1963	1,200	--
1980	1,140	1,120	1980	1,700	500
2000	1,920	1,900	2000	2,700	1,500
2020	2,640	2,620	2020	4,200	3,000

[1] Cumulative needs above the 20 wet moorages available in 1966.

[2] Cumulative waterborne commerce above total for 1963.

Source: Appendix VIII, Navigation.

Harbor and channel draft requirements and terminal/industrial land needs are shown in Table 12-12.

TABLE 12-12. Harbor and channel and terminal and water transport-oriented industrial land requirements, Elwha-Dungeness Basins

	Harbor and Channel Req. (vessel draft in feet)			Terminal and Industrial Land (acres)	
Year	Freighters	Bulk Carriers	Tankers	Total	Net Needs[1]
1963	--	--	--	200	--
1980	35	--	45	480	280
2000	40	--	45	830	630
2020	40	--	45	1,170	970

[1] Cumulative needs above 1963 land use.

Source: Appendix VIII, Navigation.

Protected wet moorage development, with Federal participation in the construction of general navigation facilities would be required to meet current and future pleasure boating needs.

POWER

General

The Crown Zellerbach Corporation has two hydroelectric power plants on the Elwha River. Glines Canyon, the upstream plant, with an installed capacity of 12,000 kw, and a reservoir, Lake Mills, with 26,000 acre-feet of usable storage, was constructed in 1927. The lower plant, Elwha, built in 1911, has an installed capacity of 12,000 kw, and its reservoir, Lake Aldwell, has 27,000 acre-feet capacity with 3,000 acre-feet of usable storage. The combined usable storage of these plants is operated primarily for power with some used to augment low flows for fisheries enhancement. The hydroelectric plants are interconnected with the Bonneville Power Administration of grid and supply about half of Crown Zellerbach's power demand at Port Angeles.

There are no hydroelectric generation facilities in the Dungeness Basin and thermal power generation facilities have not been installed in either Basin.

Present and Future Needs

The energy needs for the projected population expansion will continue to increase. Additional power generation and transmission facilities would be necessary to meet these demands. There are a number of hydropower sites within the Basins where the powerhouse and generating facilities could be justified if they could be included in a multiple-purpose dam and reservoir development.

To meet the future power needs in the Basins, as in all of the Puget Sound Area, would require the addition of a number of thermal power plants, primarily nuclear fired plants. These include peaking as well as base load plants. The possibilities of a nuclear fired power plant being located in the Elwha-Dungeness Basins are unknown at this time. Further site location and environmental studies must be conducted in the Puget Sound Area before specific site selections can be made. Power needs are discussed further in the Area portion of this Appendix.

FLOOD CONTROL

General

The Elwha River flood plain contains about 750 acres of agricultural land along the lower 2 miles of the river. The existing flood control system on the Elwha River consists of flood control reservoir storage provided by voluntary draw down of the Lake Mills Reservoir by the Crown Zellerbach Corporation, two levees, and a channel improvement project. The degree of protection provided by these facilities limits the use of the flood plain lands to hay production or pasture.

Overbank flooding occurs on a frequency of about once every one to two years. Average annual flood damages are estimated at $4,000 and damages that would result from a flood with an estimated average recurrence interval of 100 years are estimated to be $51,000.

Flooding of the 2,900-acre Dungeness River flood plain occurs on an average frequency of about once every four years. The flood plain is used predominantly for agricultural enterprises, but also contains some residences and summer homes. Average annual flood damages are estimated to be $24,000 and the damages that would result from a flood with an estimated average interval of recurrence of 100 years is estimated to be $600,000.

Table 12-13 lists the peak discharges and recurrence intervals of recent major floods and projected 50 and 100-year floods at Sequim on the Dungeness River and McDonald Bridge on the Elwha River. Estimated flood damages are based on 1966 prices and conditions.

TABLE 12-13. Major floods and estimated damages, Elwha-Dungeness Basins

DUNGENESS RIVER

	Peak Discharge at Gage Near Sequim (cfs)	Average Recurrence Interval (years)	Current Estimated Damages
Estimated	14,600	100	$600,000
Estimated	11,700	50	330,000
15 Jan. 1961	8,400	20	110,000
27 Nov. 1949	6,820	11	48,000
3 Nov. 1955	6,750	11	43,000
29 Jan. 1960	6,380	10	32,000
11 Feb. 1924	6,340	10	32,000
31 Jan. 1924	5,530	7	16,000
28 Dec. 1937	5,380	6	13,000

ELWHA RIVER

	Peak Discharge at MacDonald Bridge Gage (cfs)	Average Recurrence Interval (years)	Current Estimated Damages
18 Nov. 1897	41,600	100	$ 51,000
27 Mar. 1901	33,600	40	29,000
11 Mar. 1900	30,200	24	21,000
26 Nov. 1949	30,000	25	21,000
21 Dec. 1933	26,700	16	14,500

Source: Appendix XII, Flood Control.

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COMPREHENSIVE STUDY OF WATER AND RELATED LAND RESOURCES. PUGET --ETC(U)
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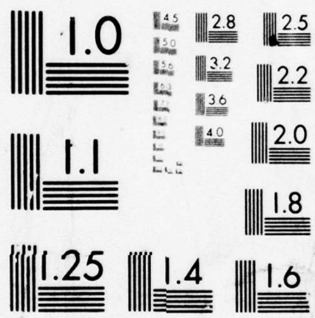


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Zoning and regulation of the flood plain as an alternative and complementary means of reducing flood damages have not yet been adopted for the Basins, but are needed.

The same coastal watersheds which discharge directly into the Strait of Juan de Fuca have, generally, excellent cover and flooding and bank erosion problems are minor.

Present and Future Needs

The Elwha River Basin is expected to be utilized predominately as a recreational area with agriculture, forest products and hydroelectric power production continuing as important industries. The increasing demand for recreation in the Puget Sound Area would result in rapid recreational growth in this Basin. Future average annual flood damages are expected to increase in proportion to the increase in economic activity in the flood plain if additional protection is not provided.

Future average annual overbank flood damages on the 2,900-acre flood plain of the Dungeness River are expected to increase in proportion to the increase in economic activity in the flood plain if additional protection is not provided. The projected trend of development within the Basin would result in flood damages approximating 1.6 percent compounded annually without flood control and would result in future growth of annual damages as shown in Table 12-14.

TABLE 12-14. Projected flood damage reduction needs,[1] Elwha-Dungeness Basins

Year	Basins: Elwha ($1000)	Basins: Dungeness ($1000)	Total ($1000)	Net Needs[2] ($1000)
1966	4	24	28	28
1980	5	30	38	38
2000	7	42	54	54
2020	9	57	80	80

[1] Based on 1966 prices and conditions.

[2] Damages which would occur without additional measures.

Source: Appendix XII, Flood Control.

WATERSHED MANAGEMENT

General

Watershed management includes treatment measures for flood prevention, watershed protection and rehabilitation and water management. The need is for implementation of integrated programs and projects for floodwater damage prevention and water management, with rehabilitation and protection of watershed lands regardless of use. The implementation of integrated programs and projects would meet the primary objectives and enhance water quality improvement, municipal and industrial water, fish and wildlife habitat, recreation, and the general environment of the Basins.

Present and Future Needs

The needs for watershed management are complex, and two or more practices and measures may be required on the same area of land. Many measures and treatments become involved in integrated programs and projects. The watershed management needs for the Basins are tabulated in Table 12-15.

TABLE 12-15. Total watershed management needs, Elwha-Dungeness Basins

Year	Flood Prevention[1] (acres)	Watershed Protection and Rehabilitation (acres)	Water Management: Agriculture (acres)	Water Management: Urban (acres)
1980	15,900	446,600	9,600	11,000
2000	15,900	446,600	16,100	11,000
2020	15,900	446,600	21,400	11,000

[1] Includes flooding on main streams but not forested land within flood plain areas.

Source: Appendix XIV, Watershed Management.

RECREATION

General

The location, semi-arid climate, recreational resources and opportunities make the Basins an ideal recreation area. There are 19 publicly-administered outdoor recreation sites and at least 96 private operators offering facilities for public recreation use. In addition to developed sites, over 300,000 acres of publicly-administered lands are available for public

recreation use. About one-half of this acreage will be maintained as wilderness with minimal developments. The U.S. Fish and Wildlife Service manages the 226-acre Dungeness National Wildlife Refuge on Dungeness Spit. Recreation use to this area increased from 5,000 visits during 1964 to 10,000 visits in 1966.

The main recreation attractions of the Basins are the salt water, rivers and streams, and the spectacular Olympic Mountains. Hurricane Ridge is a popular destination for recreationists. In the lower elevations recreationists enjoy camping along the streams and salt water shoreline; fishing for salmon, steelhead, and trout; fishing for dungeness crab; hunting for deer, elk, and game birds; gathering mushrooms, berries, and wild flowers; boating; and viewing the scenery. In the high country, sightseeing, hiking, mountain climbing, high lake fishing, snow skiing and other related activities available in alpine areas are popular.

Present and Future Needs

The present and future water related demand expressed in recreation days is shown in Table 12-16.

TABLE 12-16. Present and projected water-related recreation demand, Elwha-Dungeness Basins (1000's recreation days)

Year	Total	Net Needs[1]
1960	650	250
1980	1,300	900
2000	2,500	1,850
2020	4,600	3,950

[1] Cumulative needs above 400,000 recreation days satisfied by facilities existing in 1960.

Source: Appendix X, Recreation.

The existing supply of recreational developed lands is inadequate to satisfy the 1960 boating and picnicking demands. There is a deficiency of beaches and pools to satisfy 1960 swimming demands. An additional 925 rental moorage spaces were needed to satisfy 1966 boating demands. With the exception of swimming pools needed in urban areas, existing waters within the Elwha-Dungeness Basins will satisfy all foreseeable water based recreation needs. Urban parks, scenic routes, waterfront access, harbors of refuge, recreation rivers, special interest areas, interpretive facilities, open spaces, and beaches and trails for activities other than swimming and hiking are necessary to satisfy the recreation and environmental needs of the people.

FISH AND WILDLIFE

General

The Elwha-Dungeness Basins contain considerable spawning and rearing areas for anadromous fish. Such area exists not only in the Elwha and Dungeness Rivers, but also in many of the smaller streams directly tributary to the Strait of Juan de Fuca. Due to the location of Elwha Dam, use of the Elwha River for spawning is limited to the lower 4 miles of the main-stem and less than 2 miles of tributaries. Resident game fish are found in all stream areas inhabited by anadromous species in addition to areas above migratory blocks.

There are two power dams on the Elwha River. There are no fish passage facilities at these dams. These dams are owned and operated by Crown Zellerbach Corporation. Sometime in the early 1930's Crown Zellerbach arrived at an informal agreement with the State fisheries representatives to provide a minimum flow of 30 cfs through the entire lower reach of the Elwha River for salmon. This minimum fish flow requirement is not a condition of the 150 cfs industrial diversion right.

Anadromous fish utilize approximately 16 miles of main-stem Dungeness plus more than 15 miles of its tributaries. A principal limiting factor to anadromous fish production in the Elwha River is the lack of access to the upper reaches of the river.

Conditions are poor at the mouth of the Dungeness River for fish use in water depth, flow, and temperature particularly during low tide cycles. The principal limiting factor to fish production in the Dungeness River is the low summer and autumn streamflows.

Nearly all species of big game, upland game and waterfowl found in the State of Washington are in the Basins.

Present and Future Needs

The greatest enhancement for fish production from the Elwha River involves the need to increase

the utilization of the area below Elwha Dam as well as passage to and rehabilitation of the river and reservoirs above Elwha Dam and Glines Dam.

The greatest enhancement for fish production from the Dungeness River involves the need to increase the extreme low flows prevalent during August and September which seriously limit the chinook, coho and steelhead production. Augmentation of these low flows could substantially enhance rearing survival and improve upstream migrations of adults.

Liberations of fish in waters of Olympic National Park should be commensurate with the increased angling demand anticipated during future years. Continued coordination of necessary management programs would need to be maintained between the State of Washington and National Park Service.

Loss of forest and agricultural lands to intensive land use will reduce wildlife habitat and hunter recreation to some degree. Emphasis must be directed toward retention of those areas where the wildlife potential is the greatest. The greatest potential in the Basin exists in the low elevation areas where all uses of land are generally in conflict.

The fishing and hunting needs in terms of user-days and commercial pounds are summarized in Table 12-17.

TABLE 12-17. Fish and wildlife, sport and commercial needs, Elwha-Dungeness Basins

	Unit	1965	1980		2000		2020	
		Total	Total	Net[1]	Total	Net[1]	Total	Net[1]
Sport Fishing								
Salmon	1000 User-Days	98	162	64	298	200	506	508
Game Fish	1000 User-Days	112	187	75	294	182	471	359
Marine Fish	1000 User-Days	2	3	1	4	2	5	3
Shellfish	1000 User-Days	12	17	5	22	10	29	17
Total		224	369	145	628	394	1,011	887
Hunting	1000 User-Days	26	50	24	81	55	99	73
Commercial Fishing	1000 Pounds	–	--	922	--	1,441	--	1,643

[1] Cumulative need above 1965 activity.

Source: Appendix XI, Fish and Wildlife.

COMPREHENSIVE PLAN

BASIS OF PLANNING

Desires of Local People

At the public hearings held in Olympia on 20 October 1964, local interests expressed the needs for developing the Dungeness Spit area into a multiple-purpose recreational area including facilities for expanding the fish farm program of the Department of Fisheries. Additional boat harbor and moorage facilities, along with expanded recreational facilities throughout the Basin, were desired. The development of an additional industrial water supply for Port Angeles was stressed as the Morse Creek development could not supply all of the city's future water needs. Others asked for enhancement of the anadromous fish runs in the Elwha River, flood plain zoning, expanded port facilities, and the preservation of the streams for fish spawning.

Summary of Basin Needs

The needs of the Elwha-Dungeness Basins for 1980, 2000 and 2020 are summarized in Table 12-18.

TABLE 12-18. Summary of needs, Elwha-Dungeness Basins

Feature	Units	Cumulative Net Needs[1] 1980	2000	2020
M&I Water Supply	MGD	75.5	144.8	207.0
	(1000 Acre-Feet)	83.7	162.8	231.0
Irrigation	1000 Acre-Feet	29.1	29.1	29.1
Water Quality Control				
Waste	1000 Population Equivalents	2,681	2,856	2,812
Flow	cfs	0	0	0
Navigation				
Commercial	1000 Short Tons	500	1,500	3,000
Pleasure Boats	Wet Moorages	1,120	1,900	2,620
Power[2]				
Flood Control	$1000 Damage Reduction	38	54	80
Watershed Management[3]				
Flood Prevention	1000 Acres	15.9	15.9	15.9
Rehabilitation and Protection of Watersheds	1000 Acres	446.6	446.6	446.6
Water Management				
Agriculture	1000 Acres	9.6	16.1	21.4
Urban	1000 Acres	11.0	11.0	11.0
Recreation	1000 User-Days	900	1,850	3,950
Fish and Wildlife				
Sport				
Fishing	1000 User-Days	145	394	887
Hunting	1000 User-Days	24	55	73
Commercial Fishing	1000 Pounds	922	1,441	1,643

[1] See Water and Related Land Resource Needs section for derivation of net needs.

[2] Power needs have been projected for the Puget Sound Area only.

[3] Total acreage in basin involved in program measures.

General Planning

In the Elwha-Dungeness Basins there are adequate water and related land resources to meet their present and future requirements. It is recognized that Congressional restraints imposed upon developments inside a National Park limits the range of opportunities. However, all opportunities were investigated including those inside the National Park.

A wide range of alternative nonstorage and management opportunities were viewed in the Elwha-Dungeness Basins. These included but were not limited to diversion structures, direct river pumping and treatment, desalinization, inter-basin water transfer, further ground water utilization, and improved water yields through various watershed management practices to satisfy water supply needs of municipalities and industry, irrigated farming, water quality preservation and enhancement, and fish use. Levees, channelization, diversion, flood plain evaluation, bank protection, and improved land use management practices were considered as possible means of meeting flood control and watershed management needs. Opportunities considered for satisfaction of water quality needs were sewage collection and treatment facilities and minimum flows available to assimilate residual wasteloadings.

The water and related land resource was examined in terms of projected land use pattern C_2 (see Projected Land Use) with the land needs of navigation, power, recreation, and fish and wildlife considered within this context.

There are limited storage sites on the Basins rivers and streams which could provide opportunities for water control and to more fully utilize the resource in meeting water supply needs and minimum streamflow requirements for anadromous and resident fish. Main-stem storage could be developed at sites on the Elwha and Dungeness Rivers. Existing storage reservoirs could be enlarged or their operations modified. Construction of small off-stream reservoir impoundments for use in conjunction with existing or new storage could provide additional water supply and flow augmentation. These off-stream reservoirs could be compatibly developed to provide pumped-storage for hydroelectric power generation also. With storage there would be sufficient quantities of water to meet projected water supply needs even during a year of extreme low runoff without reducing streamflows below historical minimums during critical periods for fish. For further information on minimum streamflows for fish see the Area discussion on Fish and Wildlife.

Alternative objectives were considered in developing the Comprehensive Plan. The objectives represented both ends of the spectrum of interests, i.e., economic efficiency and environmental quality as discussed in the Puget Sound Area section of this Appendix. The alternative elements considered in plan formulation are described under Alternative Elements.

The single-purpose Appendices, V through XIV, provided a wide array of solutions. Necessary adjustments were made to these solutions in the formulation of a comprehensive plan for the Basins. These adjustments consisted of:

(a) In Appendix VI, Municipal and Industrial Water Supply, expansion of Morse Creek water supply system, addition of a Ranney well, and storage on the Elwha River were developed in lieu of utilizing ground water, and direct diversion from the Elwha River.

(b) To provide the fish flows as contained in Appendix XI, Fish and Wildlife, part of the existing storage in Lake Aldwell would be used to help satisfy these needs.

Placing the existing irrigation system in pipe in the Dungeness Basin would provide low flow augmentation for fish in the Dungeness River.

SUMMARY OF PLAN

Early Action 1970-1980

The sources of water supply for the Elwha River Basin are adequate through year 1980. To meet the projected increase of production at the Port Angeles pulp mills prior to 1980, the self-supplied industrial water diversion and conveyance facilities from the Elwha River will require enlarging.

To circumvent the spring turbidity problem on Morse Creek, Port Angeles is expected to provide a Ranney Well near the Elwha River to an approximate capacity of 5 mgd prior to 1980. The Ranney Well water supply would supplement the Morse Creek supplies.

The city of Port Angeles must enlarge their system delivery capability to meet the peak day demands and fire control needs. The system delivery capability is projected to be 14.7 mgd by year 1980.

The water supply system for Sequim and the small rural community water systems should be enlarged to provide the peak flow and fire protection delivery capability outlined in the State's water supply system standards.

The projected water supply and streamflow needs in the Dungeness River Basin can be met by modernizing or updating the existing irrigation system. The updated irrigation system would consist of a closed pipe conveyance and distribution system capable of supplying water by gravity at sprinkler pressure to an irrigable area of 22,000 acres. This includes 6,100 acres of lands which are not now irrigated.

Streamflow in the Dungeness River would be increased during the critical summer months. Under present day diversions, this would leave in the river an additional 31,000 acre-feet during the summer months over that which presently exists. This volume is nearly equal to the entire present combined mean monthly flow of August, September, and October. The additional streamflow would provide an adequate transportation flow for fish along the entire reach of the river and increase the rearing potential for both resident and anadromous fish.

With the irrigation system in pipe, certain sections of the present open irrigation ditches could be utilized for additional spawning and rearing area

for anadromous fish. A steelhead rearing pond would be part of the early action program. Ten miles of streambank access and 250 acres of waterfowl habitat would be acquired to enhance angler and hunter success. Cooperative landowner-hunter programs would be developed to insure access to prize hunting grounds.

To comply with Washington State water quality standards, waste treatment and sewer outfall facilities would be installed by the various industries for treating industrial wastes prior to discharge into the off-shore waters. Water quality surveillance is an essential element of the water quality program. Stations should be maintained at Ediz Hook, Pilot Station, the pulp mills outfalls, the ferry dock, Morse Creek and Dungeness Spit to regularly measure the water quality characteristics. The Elwha and Dungeness Rivers flow for the greater part of their length through a natural sanctuary, Olympic National Park, where outdoor recreation is the primary use. Hence, wasteloading would be light and minimum flows for other purposes such as fish will be sufficient to maintain a desirable water quality. A continuing program of expanding waste treatment and sanitary sewers in all municipalities and small community systems would be necessary to keep pace with an expanding population.

To meet the rapidly increasing demand of boating enthusiasts and satisfy part of the existing unmet needs, 710 wet moorages would be provided at new boat harbors located near the Elwha River and near the Dungeness River. To meet the projected commercial navigation needs, a continuing program of land acquisition and facility development would be necessary by the Port of Port Angeles.

Flood plain regulations would be established to reduce existing and potential flood damages and permit optimum agricultural use of the 750-acre Elwha River flood plain and the 2,900-acre Dungeness River flood plain. Levees would be provided as they are needed and are economically justified.

Other water resource needs would be met by the progressive development and implementation of watershed management programs; particularly agricultural and urban water management, with agricultural and forest rehabilitation and protection measures. No specific projects are planned for the early action time period.

The plan for recreation would provide for land and facility developments interspersed throughout the Basin and along the shoreline bordering the Strait of Juan de Fuca. Dungeness Spit would be obtained for limited recreational use commensurate with its present use as a wildfowl refuge.

Fish passage facilities would be constructed at Elwha Dam which would permit the introduction of various salmon species to the hitherto inaccessible area of the Elwha River above Elwha and Glines Canyon Dam. Both the upstream and downstream migrants would be transported around these dams.

Other early action measures which would be undertaken to increase production of fish and wildlife, would be to provide a spawning channel, develop a fish hatchery capable of being expanded, rehabilitate and fertilize Lake Sutherland, acquire 25 miles of streambank access along the Elwha and independent drainages to insure public access to these areas, develop 250 acres of waterfowl habitat and implement programs to stress value of the fish and wildlife resources.

Long-Range 1980-2020

Additional water supplies for industry and streamflow for fish in the Elwha River would be obtained by modifying the use of the 30,000 acre-foot Lake Aldwell formed by Elwha Dam. Outlet works would be placed in the left abutment with adequate capacity to meet the projected downstream fish flows and industrial water demands. The full water requirements can be met most of the time under the proposed operation, but not fully during the critical period of record (1935-1946). Even with reduced fish flows, the total projected water requirements cannot be met with upstream storage 100 percent of the time.

The 1,600 cfs outlet facilities would permit the present 3,000 acre-foot active pool to be increased to 29,500 acre-feet. The modified operation would alter the existing average summer recreation pool by less than 20 acres. It is not expected to change the projected recreation or angler-day use of the reservoir.

The present electric power generation facilities in Elwha Dam would be retained. A maximum annual power benefit foregone of $130,000 would be attributed to the project if the power facilities were totally removed.

The municipal water diversion facilities on Morse Creek would be enlarged to the ultimate

capacity of 14 mgd. The conveyance facilities from the diversion to Port Angeles would be enlarged to meet peak requirements necessary.

During this period the municipal and domestic water supply systems should be expanded to keep pace with the population growth. The Dungeness River water supplies are adequate to meet Sequim's year 2020 needs.

A planned program of expanding existing and constructing new municipal and industrial waste treatment and sanitary sewer facilities commensurate with a water quality surveillance program would be necessary to meet and maintain Washington State water quality standards.

Prior to year 2000, an additional 350 wet moorages would be provided at the small boat harbor near the Elwha River, 150 wet moorages at the existing small boat harbor in Port Angeles and an additional 1,000 salt water wet moorages at a new small boat harbor located near the mouth of the Dungeness River.

A continuing program of land acquisition for water oriented industry and terminal facility development would be necessary by the Port of Port Angeles. During the period 1980-2020, 1,170 acres of additional land would be needed to meet the projected commercial navigation business volume.

A flood plain management program would be continued. Twenty-five year flood protection would be provided to 2,200 acres of the 2,900-acre flood plain after year 2000 with the construction of levees along the lower 8 miles of the Dungeness River.

A 7,000-foot levee along the right bank of the Elwha River would provide 25-year protection to 750-acre flood plain. Incidental flood protection in excess of the 25-year flood would be obtained with the modified operation of Lake Aldwell reservoir.

Prior to year 2000 small watershed projects would be provided near Port Angeles, along the Dungeness River, McDonald, Morse and Siebert Creeks. Upgrading of existing facilities and more intensive application of recurring and nonrecurring land treatment practices would be required throughout the Basins. Watershed management programs which offer technical assistance and financial participation in local land and water related projects and programs would be continued. After year 2000 small watershed protection projects would be provided along Ennis Creek and the Lower Elwha River.

An additional 1,280 acres of land with appropriate facilities would be acquired and developed for recreational use. The upper reaches of the Elwha, Dungeness, and Grey Wolf Rivers, and the Tyler Peak scenic area would be retained in their natural state.

Additional fish and wildlife objectives would be satisfied with new salmon and steelhead rearing impoundments, stream channel clearance, channel cross-section improvements, fish passage over natural barriers, and improvement of wildfowl habitat.

Table 12-19 summarizes the elements of the Comprehensive Plan for the Elwha-Dungeness Basins, showing the benefits and costs for the early action program (projects and programs required by 1980), and provides a summary of investment costs by water resource functions for the entire 50-year period ending in 2020. The early action plan includes programs amounting to $18,409,000 and projects costing $41,447,000 for a total investment of $59,586,000. Program and project investment costs for the 1980-2000 period amount to $58,572,000 and for the 2000-2020 period $72,273,000 for a total 50-year investment of $190,701,000.

TABLE 12-19. Comprehensive Plan, Elwha-Dungeness Basins

Feature	Item	1970-1980 Investment[1] Costs ($1000)	Average Annual Costs ($1000)	Average Annual Benefits Gross ($1000)	Average Annual Benefits Net ($1000)	1980-2000 Investment Costs ($1000)	2000-2020 Investment Costs ($1000)	1970-2020 Investment Costs ($1000)
Management Programs								
Water Quality Control	Monitoring, Evaluation and Control Programs	350				440	520	1,310
Flood Control	Flood Plain Management	31				20	20	71
Watershed Management	Programs	17,852				23,229	24,437	65,517
Fish & Wildlife	Programs	176				309	300	785
Total Programs		$18,409				$23,998	$25,277	$ 67,684
Nonstorage Projects								
M&I Water Supply	Ground Water Use	24	6	6[4]	0	18	18	60
	Surface Water Use	1,440	1,673	1,673[4]	0	2,660	830	4,930
Irrigation	Surface Water Use	15,380	897	1,467[4]	570	0	0	15,380
Water Quality Control	Waste Treatment and Collection Facilities	13,595	713	713[4]	0	9,760	21,300	44,655
Navigation	Small Boat Harbors	(1,434)[3]	(92)[3]	(133)[3]	(41)[3]	(1,613)[3]	(1,411)[3]	(4,458)[3]
Power[2]								
Flood Control	Levees	0	0	0	0	0	2,750	2,750
Watershed Management	Damage Reduction, Protection and Rehabilitation, and Water Management	0	0	0	0	2,962	300	3,262
Recreation	Land Acquisition, Access and Facilities	8,259	698	1,125	427	12,700	19,800	40,759
Fish & Wildlife	Production Enhancement Facilities, Access and Acquisition	2,749	282	1,758	1,476	3,474	1,998	8,221
Total Nonstorage		$41,447	$4,269	$6,742	$2,473	$31,574	$46,996	$120,017
Storage Projects	Elwha Dam and Reservoir							
Industrial Water Supply		0	0	0	0	1,500	0	1,500
Fish & Wildlife		0	0	0	0	1,500	0	1,500
Total Storage		$ 0	$ 0	$ 0	$ 0	$ 3,000	$ 0	$ 3,000
Total Programs and Projects		$59,856	$4,269	$6,742	$2,473	$58,572	$72,273	$190,701

[1] *Includes cumulative annual program costs for the period for management features and capital costs for nonstorage and storage projects.*

[2] Power facilities not included in basin plan.

[3] General Navigation facilities cost and benefits for public small boat harbors only. Total pleasure boat facilities costs and benefits included with Recreation.

[4] Average annual benefits assumed equal to average annual costs.

FEATURES OF THE COMPREHENSIVE PLAN

Municipal and Industrial Water Supply

The Basins have adequate water sources and supplies to meet 1980 demands. After this period upstream storage, expansion of distribution systems and pumping would be necessary. Morse Creek watershed is capable of meeting the municipal and some industrial requirements for Port Angeles through year 2020. The conveyance facilities to the city must be enlarged to meet the projected peak day and fire control demands. By 2020 the population density is not expected to reach a level where a county or regional water supply and transmission system would be required.

1970-1980—In order to circumvent the spring turbidity problem in Morse Creek, a 5 mgd Ranney well should be constructed by the city near the Elwha River. The well would provide an acceptable water supply during this short period of time when Morse Creek is turbid. The well should be developed to a sufficient capacity to meet the city's year 2000 average daily demand and is expected to be operational by 1980.

The self-supplied industrial water supplies are considered adequate until 1980. However, the diversion facilities at the Elwha River and the conveyance pipeline to the pulp industries in Port Angeles would need to be enlarged from 70 mgd to 134 mgd by 1980.

The existing water sources and supplies for the small towns in the Basins are adequate for future development. The water supplies are adequate to meet the Basins projected municipal needs to year 2020. Construction by the town of Sequim of additional capacity and improvements to storage within the distribution system would meet that city's needs to year 2020. Ground water supplies can be economically utilized by the rural-individual or small community water systems.

Investment and annual costs for 1980 are shown in the following tabulation:

Development	Needed by Year	1980 Average Daily Water Use (mgd)	Total System Capability (mgd)	Supply, Transmission & Treatment Investment ($1000)	Average Annual Costs Investment ($1000)	Average Annual Costs O&M[1] ($1000)	Average Annual Total ($1000)	Average Annual Benefits[2] ($1000)
Port Angeles								
Construction of 5.0 mgd Ranney Well	1975	4	20	360	17	57	67	67
Sequim								
Increase delivery capability	1975	0.8	1.4	24	1	5	6	6
Rural and Community Systems								
System enlargement	1970	0.6	1.3	24	1	5	6	6
Additional ground water development	1975	0.2		6	0.4	3	3	3
Self-Supplied Industry								
Enlarge diversion and conveyance facilities	1970	134	145	1,000	47	1,543	1,590	1,590
Total		139		$1,464	$66	$1,613	$1,672	$1,672

[1] Total incremental increase above present. Includes pumping and treatment costs.

[2] Average annual benefits assumed equal to average annual costs.

1980-2000–During this period additional water supplies would be provided to the industrial users from storage in Lake Aldwell. To provide the additional industrial water, outlet works would be provided at Elwha Dam to give the 30,000 acre-foot reservoir an active capacity of 29,500 acre-feet. Present active capacity is 3,000 acre-feet. The outlet works and dam modification is estimated to cost $3,000,000.

Enlarged diversion works and pipeline conveyance facilities from the river to the industrial users would be necessary prior to year 2000. The water requirements for the industrial users are projected to increase approximately 100 cfs every 20 years.

Elwha Dam and the reservoir, Lake Aldwell, is owned by the Crown Zellerbach Corporation. Use of the dam and reservoir for multiple-purpose uses such as supplying the industrial water supplies, recreation and streamflow augmentation for fish, could be accomplished through agreement with the Crown Zellerbach Corporation, or through "recapture" proceedings of the Federal Power Commission. It would be advantageous for the pulp and paper industries to use the reservoir in meeting their future water supply needs and for other multiple-purpose uses as water supplies for expansion are very limited. If an agreement for the use and subsequent modification of the dam and the reservoir operation cannot be worked out between the competing users, then a proposal could be made to the Federal Power Commission requesting assistance through their regulating powers of licensing of power dams and facilities. The Elwha Dam and power facilities have not been licensed by the FPC and their operation could be altered for multiple-purpose uses at an early date should the FPC so rule.

The Port Angeles municipal water supply facilities on Morse Creek would need to be enlarged prior to year 2000. The enlarged facilities would consist of additional storage capacity on Morse Creek and transmission facilities to Port Angeles.

To keep pace with the population influx the existing municipal and rural community systems would require enlarging.

A summary of projected average daily water use and investment costs is shown in the following tabulation for municipal and industrial water supply developments required by the year 2000.

Development	Needed by Year	2000 Average Daily Water Use (mgd)	Total System Capability (mgd)	Supply, Transmission and Treatment Investment ($1000)
Port Angeles				
Morse Creek enlargement	1995	8	27	1,820
Sequim			0	0
Rural and Community Systems	1995	0.7	0.3	18
Self-Supplied Industry	1990	201	221	840
Total		210		$2,678

2000-2020–Expansion of Sequim's water supply system including storage of 1.3 mgd is projected for this period. The present water supply source is adequate for ultimate development. The self-supplied industrial water users would be required to enlarge their transmission system to meet year 2020 demands of 257 mgd. A continuing expansion of the domestic and rural community systems would be necessary. A summary of projected average daily water use and investment costs are shown in the following tabulation:

Development	Needed by Year	2020 Average Daily Water Use (mgd)	Total System Capability (mgd)	Supply, Transmission and Treatment Investment ($1000)
Port Angeles				
Additional treatment facilities	2010	11	31	186
Sequim	2010	1	3	78
Rural and Community Systems				
Systems enlargement	2015	2	1.9	18
Self-Supplied Industry				
Systems Enlargement	2010	257	283	566
Total		271		$848

The ability of the industrial water users to reuse fresh water in their product process or use salt water for cooling and air washing functions and thereby reducing fresh water demands was not evaluated in this Study. These factors should be considered in planning by the industries concerned.

Irrigation

Future irrigation development is expected to occur along the Dungeness River plain and eastward to approximately Morse Creek. The future water supplies are expected to be obtained from the Dungeness River. Some supplemental water supplies in scattered locations may be obtained from ground water or from creeks. These supplemental supplies are expected to be minimal and were not considered to be a significant contribution in developing the overall irrigation water supplies. Irrigation expansion is projected to reach ultimate development by 1980 and remain constant thereafter.

1970-1980—To satisfy the future irrigation water supply demands the selected type of development provides for an updated, closed pipe distribution system to provide water by gravity at sprinkler pressure for an irrigable area of 22,000 acres. This includes 6,100 acres of lands not now irrigated. These lands are now in various stages of development, ranging from uncleared, timbered tracts to lands presently irrigated but varying widely in adequacy of water supply. Presently 15,900 acres are irrigated. With the updated system, all lands would have an adequate and dependable water supply.

Water for the irrigation system would be provided by direct diversion of natural flows into project laterals, one on each side of the river, leading to two elevated regulating reservoirs near Sequim, beyond which water would be conveyed to the farmlands through a pipe distribution system. After the water is delivered to the farmer's headgate, a farm distribution system would be necessary. The individual farm system would consist of mainline and lateral pipe, sprinkler heads, raisers, and valves.

The total project cost and benefits are shown in the following tabulation:

Year	Development	Investment Costs ($1000)	Average Annual Costs: Interest & Amortization ($1000)	Average Annual Costs: Operation & Maintenance ($1000)	Average Annual: Total ($1000)	Average Annual: Benefit ($1000)
1980	Project	14,610	684	117	801	
	Individual Systems	770[1]	59	37	96	
	Total	$15,380	$743	$154	$897	$1,467
2000		0	0	0	0	
2020		0	0	0	0	

[1] Costs based on supplying water to 900 acres presently flood irrigated plus 6,100 acres not presently irrigated.

The water presently diverted and that conserved with the updated irrigation system is shown in the following tabulation:

Month	Diversion (1000 acre-feet): Present (15,900 acres)	Diversion (1000 acre-feet): With Pipe System (22,000 acres)	Water Saved: 1000 ac. ft.	Water Saved: cfs
May	4.5	3.6	0.9	15
June	17.2	13.8	3.4	57
July	21.8	17.4	4.4	72 (70)
August	15.8	12.6	3.2	52 (50)
September	11.2	9.0	2.2	37 (35)
October	4.5	3.6	0.9	15 (15)
Total	75.0	60.0	15.0	

The water conserved during the dry summer months would provide augmentation and enhancement benefits for fish. These benefits are discussed under Fish and Wildlife.

The annual diversions and depletions are shown in the following tabulation:

Year	New Irrigation (acres)	Diversions: Surface Water (1000 ac. ft.)	Diversions: Ground Water (1000 ac. ft.)	Depletions: Surface Water (1000 ac. ft.)	Depletions: Ground Water (1000 ac. ft.)
1966		75	--	75	--
1980	6,100	60	--	60	--
2000	0	60	--	60	--
2020	0	60	--	60	--

Providing the irrigation facilities would meet the irrigation objectives of the Basin.

Water Quality Control

A large investment would be required to meet the present and future waste collection and treatment requirements in the Basins. Studies show that the minimum historical Elwha and Dungeness River flows would adequately assimilate projected residual wasteloadings without deteriorating water quality.

1970-1980—Waste treatment facilities would be provided at the recreational developments on the shores of Sequim Bay and in small communities throughout the Basins.

The city of Port Angeles has recently completed installing a primary treatment plant for treating municipal effluent prior to discharge in Port Angeles Harbor.

Facilities would have to be installed in each of the industrial plants to treat their wastes prior to discharging it to the Basins' offshore waters. The treatment requirements as outlined in the Washington State Water Quality Standards and Implementation Plan of December 1967 should be adhered to. These are discussed as follows:

Pen Plywood Corporation—Provide in-plant treatment for the removal of glue wastes, and then all wastes are to be intercepted by a municipal system.

Rayonier, Inc. and Fibreboard Paper Products Corporation—Provide primary treatment facilities to remove all settleable solids from mill effluents prior to discharge into Puget Sound; adequate facilities for

the disposal of recovered solids or sludge; a submarine outfall equipped with an adequate diffuser to permit discharge of all residual wastes into deeper waters to achieve maximum dilution and dispersion; and removal to land by dredging of the existing sludge bed in the waterways adjacent to each mill.

Crown Zellerbach Corporation–Design and construct facilities and provide in-plant controls similar to Rayonier and Fibreboard. A settling lagoon for log barker effluent should also be provided.

These waste collection and treatment requirements would abate water pollution in Port Angeles Harbor and in the Strait of Juan de Fuca.

A substantial investment in waste treatment and sanitary sewer facilities would be necessary during the next 50 years to keep abreast of the needs for an expanding population influx and the projected industrial expansion.

A water quality surveillance program would be continued to insure that the harbor and offshore waters are maintained to the minimum Federal and State standards. Additional stations should be established, as proposed in the Strait, Ediz Hook, Pilot Station, the pulp mills, ferry dock, Morse Creek, Sequim Bay, the lower reaches of the Dungeness River, and the Dungeness Spit area. The annual surveillance program costs are estimated to be $3,400.

The investment costs of the treatment and sewer outfall facilities and projected surveillance program costs are shown in the following tabulation:

Water Quality Control
1970-1980

Feature	Investment Costs ($1000)	Average Annual Costs: Interest & Amortization ($1000)	Average Annual Costs: Operation & Maintenance ($1000)	Average Annual: Total ($1000)	Average Annual: Benefits[2] ($1000)
Monitoring, Evaluation and Control Program	350[1]	--	--	--	--
Municipal Wastes					
Treatment	1,000	50	1	51	51
Sewers	2,200	103	2	105	105
Subtotal	$ 3,200	$153	$ 3	$156	$156
Industrial					
Treatment	9,870	510	10	520	520
Recreation	525	36	1	37	37
Total	$13,945	$699	$14	$713	$713

1 Cumulative annual program costs for the period.

2 Benefits are assumed to be equal to the cost.

Long-Range 1980-2020—During these periods expansion by industry, new developments and growth of urban and recreation areas correspondingly would require that new sewer interception systems be installed and treatment facilities enlarged and/or constructed. Summarized below are estimated investment costs for water quality control by sectors for each period.

Water Quality Control
1980-2020

Feature	Investment Costs ($1000) 1980-2000	2000-2020
Monitoring, Evaluation and Control Program	440[1]	520[1]
Municipal		
Treatment	358	1,000
Sewers	762	2,300
Subtotal	$ 1,120	$ 3,300
Industrial		
Treatment	7,340	16,000
Recreation	1,300	2,000
Total	$10,200	$21,820

[1] *Cumulative annual program costs for the period.*

Construction of these facilities and continuance of the surveillance program would meet the water quality needs of the Basin.

Navigation

Total commerce handled by the Port of Port Angeles is expected to double by the year 2020. Accordingly, expansion of port facilities would be required to accommodate the expected traffic.

Based upon the Basins' terminal and industrial land apportionment from the Puget Sound Area, 1,170 acres would be needed by 2020. This is an additional 970 acres above 1963 use. Expected growth by the Port Angeles Harbor would necessitate that the port authorities acquire about 760 acres of additional land adjacent to the present harbor for terminal facilities and water-oriented industrial development by the year 2020. A 210-acre area near the mouth of Morse Creek has potential for water-oriented industrial development sometime after 1980.

Existing depths in Port Angeles Harbor are more than adequate to accommodate vessels expected to call at the harbor. Some extension of piers and wharves may be required to reach berthing depths for some of the deeper draft vessels.

1970-1980—Development of additional land for water transport-oriented industry is planned during this period. It is expected that the Port of Port Angeles would acquire land around the existing port and eastward as practicable.

The increased demand for small boat moorages would necessitate construction of new salt water small boat harbors by 1980. Locations near the Elwha River and Green Point are considered suitable for development of public moorages. Green Point boat harbor could be developed in its entirety providing 350 wet moorages by 1980. The Elwha River location with a potential for 710 wet moorages could be developed in two stages with the first stage providing 360 wet moorages. The additional 410 wet moorages needed by 1980 could be met with private investment.

The small boat construction sequence is considered only tentative as many factors enter into small boat harbor developments with impacts beyond the capability of the planner to foresee. The construction costs and average annual costs and benefits of the public small boat harbor projects tentatively scheduled for construction by 1980 are tabulated below:

Small Boat Harbor Projects
1970-1980

Location	Wet Moorages	Investment Costs ($1000)	Average Annual[1] Costs ($1000)	Average Annual[1] Benefits ($1000)
Elwha River east	360	727	47	67
Dungeness River	350	707	45	66
Total	710	$1,434	$92	$133

[1] General navigation facilities costs and benefits only based on 50-year economic life amortized at a 4-5/8% interest rate. Total pleasure boat facilities costs and benefits included with Recreation.

Long-Range 1980-2020—Further development of the port with expansion of terminal facilities is anticipated during this period. Small boat harbor developments would continue with the addition of 800 wet moorages by year 2000 and 700 wet moorages during the period 2000-2020. These are shown in the following tabulation:

Small Boat[1] Harbor Locations	2000 Wet Moorages	2000 Invest. Costs ($1000)	2020 Wet Moorages	2020 Invest. Costs ($1000)
Port Angeles addition	150		0	
Elwha River east	350		0	
Jamestown	300		700	
Subtotal	800	$1,613	700	$1,411
Cumulative Total above present	1,920		2,620	

[1] It is expected that due to the high construction costs, the small boat harbor projects noted would be built by public agencies with Federal aid.

The small boat harbor land and facilities investment costs and associated benefits are contained as part of the recreation plan. Obtaining the land and water areas and constructing the small boat harbor facilities carried in the recreation plan would satisfy the salt water small boat harbor needs for the Basin. Developing the harbor facilities recommended above would satisfy the navigation needs of the Basin.

Power

To meet the future energy requirements, nuclear generating plants would be required at a number of locations in the Puget Sound Area during the next 50 years. Most of the plants are projected to be located along the salt water shoreline and use offshore water for cooling. The Strait of Juan de Fuca offers an abundance of cold water for cooling. The Sequim site in the northeastern portion of the Basin is under active consideration for nuclear power development. The soils for this area resemble the Hanford outwash gravels which have proven excellent for reactor foundation materials. However, more information is required concerning currents along this area as the circulation of warm water discharge into the adjacent bays may effect the commercial and sport marine fish and shell fisheries. The tolerance of the flora and fauna to the warm water or to rapid water temperature changes is unknown at this time. These aspects must be fully investigated prior to any site selection. Additional discussion on thermal power generation is included in the Puget Sound Area section of this Appendix.

A possible geo-thermal site location in the upper reaches of the Elwha River, deep within the Olympic National Park, is listed in Appendix IX, Power, but was not evaluated for this Study due to its small potential and remote location.

In order to satisfy the projected electric power needs, energy must be imported from outside of the Basin.

Flood Control

Flood plain regulations should be adopted by the county and State which would limit or restrict the urban development on the entire flood plain consistent with existing flood protection. The purpose of the regulations would be for protecting the channels from encroachment, and to prevent or minimize material losses, and reduce the cost of relief and rescue occasioned by the unwise occupancy of such flood areas. Establishment and maintenance of a flood plain management program would partially satisfy the flood control needs of the Basin. The cost of a flood plain management program would require an initial investment of $33,000 with a continuing $2,000 annual administrative cost.

After year 2000 a set-back levee along the left bank of the Dungeness River from mile 0 to 8 would provide 25-year protection for 2,200 acres of the 2,900-acre flood plain. Cost of the levees is estimated to be $2,500,000.

A 7,000-foot levee constructed after year 2000 would provide 100-year protection to the 750-acre flood plain. Incidental flood control protection would be obtained with the modified operation of Lake Aldwell reservoir. The reservoir would provide its greatest protection during the late fall or early winter months. This is the time when the potential flooding is the greatest.

A combined storage space of 50,000 acre-feet would be necessary to control the 100-year flood below the Highway 101 Bridge. A combined operation of Lake Mills and Lake Aldwell could provide over a 50-year protection to the 750-acre flood plain but could not be economically justified.

The flood control features, costs and the sequence of development are shown in the following tabulation:

Flood Control Feature	Investment Costs ($1000) 1980	2000	2020	Average Annual Costs ($1000) 1980
Flood Plain Management				
Dungeness River Basin	27	20[1]	20[1]	1
Elwha River Basin	6	20[1]	20[1]	1
Levees				
Dungeness River—river mile 0 to river mile 8	--	--	2,500	--
Elwha River—river mile 0 to river mile 1.5	--	--	250	--

[1] Cumulative program cost for the period.

Establishment and maintenance of the flood plain management program would partially satisfy the flood control needs of the Basin until year 2000 when adequate protection would be provided.

Watershed Management

The development of resources in the Elwha-Dungeness Basins would require a watershed management program designed to reduce water damage, rehabilitate the forest stands and protect watershed areas, and provide water management for a variety of purposes on rural and urban lands.

Many structural and nonstructural measures combine to form the array of practices required to accomplish these purposes. Representative measures are described in detail in Appendix XIV, Watershed Management. While the acreage requiring treatment remains fairly constant by time periods, the intensity of treatment application, and the composition of the combined measures, varies with the inherent capability of the land as well as with the kind and intensity of use. Benefits from proper application of these measures are increased production, protection from watershed deterioration, forest fire protection and enhancement of many environmental qualities.

1970-1980—The early action program would consist of land treatment measures to accomplish specific objectives for conservation and development.

Federal and State land administrative agencies are responsible for the installation of applicable measures on land assigned to their management, while the initiative of individual property owners is required for installation of practices on lands in private ownership. Various Federal and State agencies have programs of technical and financial assistance for individuals, local organizations, and subdivisions of government. The program measures for the early action plan are shown in the following tabulation:

Watershed Management
1970-1980

Program	Area (acres)	Costs ($1000)
Technical assistance and management	435,629	
Federal, regular		7,037
Federal, accelerated		0
Subtotal		$ 7,037
Installation of practices (non-Federal)		
State and corporate		2,205
Land treatment	95,072	1,907
Water management		
Agricultural	9,644	1,761
Urban	3,661	4,942
Subtotal		$10,815
Total		$17,852

1980-2000—Due to population expansion and the need for a higher degree of management and protection, the program would be accelerated in the years after 1980 by installation of specific multiple-purpose watershed projects to reduce flood and sediment damages, improve water management, and provide rehabilitation and protection to the watershed lands. After 1980, some small watershed projects would be required for water management, protection and rehabilitation of watershed lands, and flood prevention. The program costs, project locations, and structural measures installation costs are shown in the following tabulation:

Watershed Management
1980-2000

Program	Area (acres)	Costs ($1000)
Technical assistance and management	435,629	
Federal, regular		11,487
Federal, accelerated		232
Subtotal		$11,719
Installation of practices (non-Federal)		
State and corporate		2,940
Land treatment		2,542
Water management		
Agricultural	6,429	1,227
Urban	3,556	4,801
Subtotal		$11,510
Total		$23,229

Projects[1]	Area (acres)	Structural Measures Installation ($1000)
Morse Creek	46,253	336
Port Angeles	16,240	206
Dungeness River	138,644	1,850
McDonald Creek	15,953	270
Siebert Creek	15,077	300
Total	232,167	$ 2,962

[1] Structural measures installation costs only.

2000-2020—The projects and programs needed to meet the watershed management needs during this time period are shown in the following tabulation:

Watershed Management
2000-2020

Program	Area (acres)	Costs ($1000)
Technical assistance and management	435,629	
Federal, regular		12,121
Federal, accelerated		93
Subtotal		$12,214
Installation of practices (non-Federal)		
State and corporate		2,940
Land treatment	95,072	2,542
Water management		
Agriculture	5,357	1,656
Urban	3,767	5,085
Subtotal		$12,223
Total		$24,437

Projects	Area (acres)	Structural Measures Installation ($1000)
Ennis Creek	6,076	100
Elwha River	208,370	200
Total	214,446	$ 300

There is a continuing investment needed, both public and private, to insure protection of water and related land within the Basin under projected development. This investment would be made in the form of financial assistance, technical assistance, research, education and information, and general management of the resource by the public agencies. Private investment would be contained in the foregoing programs and in the final accomplishment of the specific project measures.

Recreation

The 50 miles of salt water shoreline, many miles of rivers and streams, numerous lakes, and the Olympic National Park can fully support an expansion of recreational developments. Additional campgrounds and picnic areas are planned on National Forest land in the Basins' eastern part and on State lands in the northern part as well as within the National Park.

Through the development of suitable areas on existing publicly-administered lands, approximately half of the picnicking requirements would be satisfied on undeveloped lands, an additional 900 acres of

campground and 170 acres of picnic area would need to be developed to satisfy 2020 demands. This acreage does not include the necessary buffer zones on the periphery of developed recreation lands. Approximately one-fourth of the picnicking and camping needs by the year 2020 can be satisfied through the development of suitable areas on existing public lands.

The Basins have significant types and amount of year-round recreation areas. The primary needs are of acquiring lands and public access, and developing recreational facilities for public usage. However, some areas in the Basins need to be retained in their natural state for use by future generations.

The broad recreation goal is to promote well-planned development and protection of the existing resources and to provide an opportunity for the satisfaction of present and future outdoor recreation demands of the population. Based on Federal ownership of land, plans and programs of recreation suppliers, and expected population concentrations as well as outdoor recreation needs, the assumption is made that the Federal agencies would provide 20 percent of the future required water-related opportunities, while the State, county and local agencies, and the private sector would supply 35, 25, and 20 percent, respectively.

The recreation development would be coordinated with the State of Washington Recreation Plan during all stages of development.

To satisfy part of the recreational demands the lands and water areas which must be acquired are shown in the following tabulation.

A similar amount of land acreage in low density use would be required to act as buffer around the developed recreation areas.

Recreation Land and Water Requirements
1960-2020

		1960		1980		2000		2020	
Activity	Unit	Land	Water	Land	Water	Land	Water	Land	Water
Swimming									
Natural Waters	Acres	1	0	5	0	13	1	23	3
Pools	Square Feet	19,000	9,000	39,000	20,000	79,000	13,000	150,000	75,000
Boating Sailing and Water Skiing	Acres	8	--	28	--	63	--	118	--
Camping	Acres	0	--	98	--	398	--	898	--
Picnicking		52	--	92	--	192	--	292	--
Hiking		0	--	0	--	40	--	110	--

Source: Appendix X, Recreation.

1970-1980—During this period an additional 162 acres would be acquired and in some areas, camping, picnicking and other recreation facilities would be developed.

The recreational developments include interior roads, sanitation facilities, water supply, parking areas, access areas, etc.

A State system of recreation rivers is suggested to protect the unique rivers or river segments for public use. In the Elwha-Dungeness Basins, rivers which may qualify for study for inclusion into the State system include parts of the Elwha and Dungeness Rivers and Morse Creek.

The State owns most of the tidelands between Port Angeles and Dungeness Spit. The assumption is made that these tidelands would be retained in public ownership and access would be provided to them.

Scenic access easements should be established along portions of the salt water shoreline and along the Elwha River, and Morse, Ennis, Valley, Tumwater and Indian Creeks. Trails need to be developed within the river-side easements to accommodate recreationists.

Investments for recreation facilities other than those discussed previously are tabulated below for the various water-related improvements:

Outdoor Recreation Improvements
Present–1980

Improvements	Investment Costs ($1000)	Average Annual Costs: Interest & Amortization ($1000)	Average Annual Costs: Operation & Maintenance ($1000)	Average Annual Costs: Total ($1000)	Average Annual Benefits ($1000)
Campgrounds	1,372				
Picnic areas	385				
Beaches	60				
Swimming pools	975				
Boating facilities including small boat harbors	2,645				
Planning and design	1,359				
Subtotal	$6,796				
Land acquisition including buffer	1,463				
Total	$8,259	$503	$195	$698	$1,125

As a part of the early action program Dungeness Spit would be sought for inclusion into the recreational plan of development. The Spit can become one of the finest salt water related outdoor recreation resources within the Puget Sound Area. It is 7 miles long and includes close to 20 miles of beaches and is now included in the Dungeness National Wildlife Refuge. It serves as an invaluable haven for waterfowl from October to April. From May to September, nature-oriented recreational use would not harm the purpose for which the refuge was established. Purchase of an adjoining tract would provide better trail and road access from the mainland to the base of the Spit. The Spit is one of the few remaining, unspoiled areas in coastal Washington and would be maintained in a natural condition.

Long-Range 1980-2020—During this period the additional land and water areas necessary to meet recreational needs would be acquired and developed as needed:

Units	2000 Land	2000 Water	2020 Land	2020 Water
Acres	445	1	675	1
Miles	40	--	70	--

Recreational use of Lake Aldwell would not be affected markedly due to the proposed operational modification. The average summer recreational pool would be about 25,000 acre-feet providing a surface area of approximately 550 acres. This is about the average summer pool which exists now. Consequently, there would be no foregone recreational benefits with the projected modification of Lake Aldwell.

Utilizing the existing Lake Aldwell Reservoir for future water supply would permit retaining the remaining upstream watershed inside the Olympic National Park in its natural environment. The remaining small coastal watersheds would also be retained in their natural environment. No additional structural development facilities are projected.

The total costs for the water-related recreational lands and facilities in the Basins during the period are shown in the following tabulation:

Year	Investment Costs ($1000)
2000	12,700
2020	19,800
Total	$32,500

With no upstream storage development, the unique features of the Gray Wolf River and Dungeness River canyon would be preserved in their natural environment. The two outstanding natural areas in the Basin; Dungeness Spit and Tyler Peak scenic areas would be preserved.

Acquiring the land and developing the facilities contained in the recreational plan would satisfy the recreation needs.

Fish and Wildlife

The Elwha-Dungeness Basins offer numerous opportunities for projects and programs that, if implemented, would maintain and increase the wildlife, fish and shellfish production. The Basins contain a very important anadromous and resident fishery together with a resident wildlife population of upland birds, elk, deer and other big game. The anadromous fish inhabiting the Basins-river systems include chinook, coho, pink, chum and sockeye salmon, steelhead and searun cutthroat trout, and Dolly Varden. The distribution of anadromous fish and game habitat areas is presented in Appendix XI, Fish and Wildlife. Shellfish including crabs, oysters, and hard-shell clams are found in Basin marine waters.

Development of the fish and wildlife resource would follow a three-step planned procedure as outlined in the Puget Sound Area. Initial action would be to clear, cleanup and develop natural habitat to achieve maximum production. This would be followed by hatcheries and game farms to increase production and followed by artificial spawning and rearing areas to further increase production of both fish and wildlife species.

1970-1980—Fish passage to the Upper Elwha River is blocked by the Elwha Dam located 3.5 miles above Elwha Dam. The Elwha River and tributaries upstream of Glines Canyon Dam could support significant spawning populations of spring chinook, coho, and sockeye salmon. To permit this development adult fish passage facilities would be constructed at the Lower Elwha Dam and a downstream migrant collection system would be installed at Glines Dam prior to 1980.

The adult passage facilities would consist of a barrier dam, a collection system, and truck-haul to successfully collect and transport fish from the Lower Elwha Dam to the upper end of Lake Aldwell behind Glines Canyon dam. A floating, downstream migrant collector—similar to those employed at the Baker River project—would be placed in the reservoir immediately behind Glines Canyon dam to trap safely and collect juvenile salmon migrants on their way to the sea. The same truck-haul system could be used to transport these migrants from the collection device to the river below Elwha Dam.

The minimum streamflows necessary to achieve present fish production levels cannot be accurately determined until adequate field stream cross-section measurements are completed. However, in order to facilitate planning for the Puget Sound and Adjacent Waters Study, the Departments of Fisheries and Game provided the minimum streamflows they felt adequate to maintain existing production until the necessary field study could be completed. These flows are contained in Appendix XI, Fish and Wildlife, and are shown in the section Plan Formulation. All of the minimum streamflow needs as set forth cannot be met even with storage in either the Elwha or Dungeness Rivers. However, planning proceeded to provide the maximum streamflow for fish possible commensurate with other resource needs.

The streamflow which would be maintained 91 percent of the time after 1980, 84 percent after 2000, and 77 percent after 2020, is shown in the following tabulation:

Elwha River
Streamflow for Fishery
1980-2020

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
CFS	500	900	1,000	1,000	1,000	700	800	1,200	1,200	700	500	400

It was estimated by the Washington State Department of Fisheries that the flows appearing in the above tabulations would allow only 63 percent of the $74,310 annual salmon potential to be realized. This lost potential can be regained by providing certain channelization and streambed stabilization projects in the lower 4 miles of the Elwha River. However, the amount of streambed alteration cannot be determined until the programmed streambed cross-section studies are completed.

Angler use of Lake Aldwell would not be affected in altering the operation of Elwha Dam.

As a part of the early action program the low summer flows of the Dungeness River would be augmented by updating the existing irrigation conveyance system. The updated system would reduce present irrigation season diversions of 75,000 acre-feet by 31,000 acre-feet.

With an updated irrigation system the 1980 streamflow in the river would be greater during the summer months than that which exists today by the amounts shown in the following tabulation:

July	-	70 cfs
August	-	50 cfs
September	-	35 cfs
October	-	15 cfs

From available information, there has been no streamflow measurements taken below the irrigation diversions on the Dungeness River. Estimations of streamflow during the critical summer months range from a few second-feet to 100 second-feet. From existing records it has been determined that should the dry period (1936-1945) occur again, then with the existing diversions there would be little, if any, streamflow left in the river.

The additional streamflow which would be provided with the updated irrigation facility would be of substantial enhancement benefit to both resident and anadromous fish amounting to $765,000 annually.

With the updated system, approximately 15 to 20 miles of existing main-stem irrigation ditches could be made available as a supplemental spawning area for pink salmon, and rearing area for coho salmon. The ditches would be rehabilitated and spawning gravels placed in them. The streamflow diverted into the ditches would be returned to the river in the lower reaches. The required streamflow is unknown at this time but is estimated to be around 10 cfs.

This area has the lowest annual precipitation west of the Cascades creating an ideal situation for upland birds. Bird hunting is extremely popular in the Basins averaging approximately 8,500 man-days. Obtaining additional habitat areas and access areas are included in the early action plan.

The early action projects and programs for fish and wildlife are shown in the following tabulation:

Prior to 1980

Projects

a. Fish passage facilities around Elwha and Glines Canyon Dam.
b. Develop and construct a kokanee spawning channel.
c. Rehabilitation of Lake Sutherland.
d. Construction of an expandable resident fish hatchery.
e. Acquisition of 26,400 feet of streambank access along Elwha River below Olympic National Park boundary, 52,800 feet along Dungeness River, and 105,000 feet along the independent drainages below Olympic National Park boundary.
f. Update present irrigation system for low flow augmentation.
g. Rehabilitate 15 miles of irrigation ditches for supplemental salmon spawning and rearing area.
h. Construct one steelhead rearing pond.
i. Acquire and develop 250 acres of waterfowl habitat for hunting purposes.

Programs

j. Stream cross-section measurements to determine minimum fish flows.
k. Develop a cooperative program with private land owners for wildlife observation and hunting.
l. Develop compatible forest-wildlife management techniques.
m. Education program for proper utilization of wildlife resources.
n. Fertilization of Lake Sutherland.
o. Range and upland game surveys.
p. Develop habitat management plans.

The costs and benefits for the early action fish and wildlife plan are shown in the following tabulation:

Year	Feature	Initial Investment ($1000)	Average Annual Costs: Interest & Amortization ($1000)	Average Annual Costs: Operation & Maintenance ($1000)	Average Annual Costs: Total ($1000)	Average Annual Benefits ($1000)
1970-1980	Project	2,749	131	120	251	1,727
	Program	176	--	31	31	31
	Total	$2,925	$131	$151	$282	$1,758

1980-2000—The early action program places emphasis on obtaining facilities and natural areas to develop an expanded spawning base for fish. After 1980 the program stresses expansion and improvements of the spawning areas and development of new rearing areas for the young fish. To accomplish the latter objectives would require streambed improvement projects on 12 streams, provide fish passage facilities on one stream to open up 6 miles, stream channel clearance for 8 miles on one stream, develop 40 acres of controlled rearing impoundments, construction of a salmon hatchery and completion of stream cross-section measurements.

To enhance the hunting and wildlife values in the Basin, an expanded public educational program would be required to stress the proper utilization on new management techniques, and the continuing acquisition of key wildlife habitat and hunting areas.

The flood control levees projected for the Lower Elwha River and on the Dungeness River after year 2000 are expected to be constructed in such a manner so that they would not be harmful to the natural spawning and rearing areas within the river channel.

To meet the pheasant hunting demands in the Dungeness Basin would require expanding existing pheasant game farms located in adjacent basins.

Fish and Wildlife
Projects and Programs
1980-2000

	Invest. Costs ($1000)
Project	
a. Improve stream and streambed cross-sections, six streams—18 miles.	57
b. *Channel clearance, Dungeness* River—8 miles.	20
c. Fish passage over major barriers on Dungeness River—6 miles.	12
d. Ten acres of salmon rearing ponds.	55
e. Construct new salmon hatchery.	1,020
f. Additional fish and game facilities.	581
g. Land acquisition.	739
Subtotal	$3,474
Programs	
h. Continuation of fish programs including production and harvest of shellfish species.	85
i. Continuation of wildlife programs.	215
j. Complete stream cross-section measurements—8 miles.	9
Subtotal	309
Total	$2,783

2000-2020—During this period 30 acres of salmon rearing facilities are projected to increase chinook production by 17,000 fish and coho by 25,000 fish. Additional projects and programs would be necessary to expand the shellfish harvest, obtain streambank and beach access and acquire wildlife and waterfowl habitat. The fish and wildlife projects and programs scheduled for development prior to year 2020 are shown in the following tabulation.

Additional local programs for enhancement of fish and wildlife presently being conducted by the Department of Game and Department of Fisheries, would be continued.

Fish and Wildlife
Projects and Programs
2000-2020

Projects	Invest. Costs ($1000)
a. Develop 30 acres of salmon rearing facilities.	165
b. Land acquisition including habitat areas.	831
c. Other fish and game facilities.	1,002
Subtotal	$1,998
Programs	
d. Continuation of fish programs including shellfish enhancement.	100
e. Continuation of wildlife programs including range surveys and habitat development.	200
Subtotal	300
Total	$2,298

COST-BENEFIT SUMMARY

The program and investment costs by resource function are shown in Tables 12-20 and 12-21 with the costs distributed between Federal, State, local, and private interests. Average annual costs and

TABLE 12-20. Program investment costs,[1] Elwha-Dungeness Basins ($1000)

Feature	Private	Government Local	Government State	Government Federal	Total
			1970-1980		
Water Quality Control	55	55	165	75	350
Flood Control	0	22	6	3	31
Watershed Management	6,205	2,471	2,139	7,037	17,852
Fish and Wildlife	0	0	176	0	176
Subtotal	$ 6,260	$2,548	$2,486	$ 7,115	$18,409
			1980-2000		
Water Quality Control	68	68	210	94	440
Flood Control	0	14	4	2	20
Watershed Management	6,258	2,401	2,851	11,719	23,229
Fish and Wildlife	0	0	309	0	309
Subtotal	$ 6,326	$2,483	$3,374	$11,815	$23,998
			2000-2020		
Water Quality Control	84	84	244	108	520
Flood Control	0	14	4	2	20
Watershed Management	6,829	2,543	2,851	12,214	24,437
Fish and Wildlife	0	0	300	0	300
Subtotal	$ 6,913	$2,641	$3,399	$12,324	$25,277
Total	$19,499	$7,672	$9,259	$31,254	$67,684

[1] Cumulative annual program costs over the period.

benefits are shown for the projects recommended for implementation prior to 1980. Interest and amortization costs are based on a 100-year economic life with appropriate allowances made for major replacements. An interest rate of 4-5/8 percent was used in the economic analysis. Benefits for municipal and industrial water supply and water quality improvement were assumed equal to annual charges.

TABLE 12-21. Project investment costs[1] and cost-benefit summary, Elwha Dungeness Basins ($1000)

Feature	Investment Costs					Annual Costs			Annual Benefits	
		Government				Interest	Operation			
	Private	Local	State	Federal	Total	& Amortization[2]	& Maintenance	Total	Total	Net
			1970-1980							
M&I Water Supply	0	1,464	0	0	1,464	66	1,613	1,679	1,679	0
Irrigation	770	0	0	14,610	15,380	743	154	897	1,467	570
Water Quality Control	9,870	1,600	800	1,325	13,595	699	14	713	713	0
Navigation[3]	0	0	0	0	0	0	0	0	0	0
Power	0	0	0	0	0	0	0	0	0	0
Flood Control	0	0	0	0	0	0	0	0	0	0
Watershed Management[4]	0	0	0	0	0	0	0	0	0	0
Recreation	1,652	2,066	2,889	1,652	8,259	503	195	698	1,125	427
Fish & Wildlife	0	0	2,749	0	2,749	131	151	282	1,758	1,476
Subtotal	$12,292	$ 5,130	$ 6,438	$17,587	$ 41,447	$2,142	$2,127	$4,269	$6,742	$2,473
			1980-2000							
M&I Water Supply	0	2,678	0	0	2,678					
Irrigation	0	0	0	0	0					
Water Quality Control	7,340	560	280	1,580	9,760					
Navigation[3]	0	0	0	0	0					
Flood Control	0	0	0	0	0					
Watershed Management[4]	0	1,037	0	1,925	2,962					
Recreation	2,540	3,180	4,440	2,540	12,700					
Fish & Wildlife	0	0	3,474	0	3,474					
Subtotal	$ 9,880	$ 7,455	$ 8,194	$ 6,045	$ 31,574					
			2000-2020							
M&I Water Supply	0	848	0	0	848					
Irrigation	0	0	0	0	0					
Water Quality Control	16,000	1,650	825	2,825	21,300					
Navigation[3]	0	0	0	0	0					
Flood Control	0	275	0	2,475	2,750					
Watershed Management[4]	0	105	0	195	300					
Recreation	3,960	4,955	6,925	3,960	19,800					
Fish & Wildlife	0	0	1,998	0	1,998					
Subtotal	$19,960	$ 7,833	$ 9,748	$ 9,455	$ 46,996					
Total	$42,132	$20,418	$24,380	$33,087	$120,017					

[1] Capital project costs.

[2] Of initial investment and major replacement.

[3] Costs and benefits for pleasure boating moorage facilities included with Recreation.

[4] Investment for structural measures installation only.

SEQUENCE OF DEVELOPMENT

The projects and programs are summarized in Table 12-22 by time periods. The project numbers identify features on Figure 12-3.

TABLE 12-22. Future projects and programs, Elwha- Dungeness Basins

PROJECTS PRIOR TO 1980

Municipal and Industrial Water Supply

1. Construct Ranney well and conveyance system to Port Angeles.
2. Enlarge the industrial water supply diversion facilities and transmission pipeline and tunnel from Elwha River to Port Angeles.
3. Enlarge the transmission system for Sequim.
4.* Expand the small and rural community municipal water supply and transmission systems.

Irrigation

5. Construct new irrigation diversion, pipeline conveyance and lateral distribution system for 22,000 acres on Dungeness River plain.
6.* Install the individual farm irrigation systems required to irrigate 6,100 acres of new lands on Dungeness River plain.

Water Quality Control

7. Install in-plant waste treatment facilities at the specified industries in Port Angeles and Port Angeles Harbor.
8. Construct waste treatment facilities and sanitary sewers at Sequim, Sequim Bay, Port Angeles, and small municipalities.
9. Improvement of waste collection facilities for recreation developments including small boat harbors.

Navigation

10. Acquire additional waterfront land around Port Angeles for water related navigational development.
11. Construction of a small boat harbor development at Elwha River and Dungeness River.

Recreation

12. Development of three recreation sites below Elwha Dam on Elwha River.
13. Development of two recreation sites between Lake Sutherland and Lake Aldwell.
14. Develop two urban recreation areas along waterfront near Port Angeles.
15. Develop two salt water beach recreation areas between Port Angeles and McDonald Creek.
16. Develop recreational area at Dungeness Spit.
17. Development of one recreation site on Morse Creek and one on Siebert Creek.
18. Development of two recreation sites along Dungeness River below Sequim.
19. Development of one recreation site along Dungeness River above Canyon Creek.

Fish and Wildlife

20. Fish passage facilities around Elwha and Glines Canyon Dams.
21.* Development of a kokanee spawning channel and steelhead rearing pond.
22. Rehabilitation of Lake Sutherland.
23.* Construction of an expandable fish hatchery.
24.* Acquisition of 5 miles of streambank access Elwha River, 10 miles along Dungeness River, and 20 miles along independent drainages below Olympic National Park boundary.
25. Update present irrigation system for low flow augmentation Dungeness River.
26. Rehabilitate 15 miles of irrigation ditches for supplemental salmon spawning and rearing area.
27.* Acquire and develop 250 acres of waterfowl habitat for hunting.

PROGRAMS PRIOR TO 1980

Water Quality Control

a. Establish and operate water quality surveillance stations at key salt and fresh water locations and prepare a comprehensive sewerage plan for the Basins.

Flood Control

b. Establish and administer county-wide flood plain zoning measures under flood plain management program.

Watershed Management

c. Provide technical assistance and management for State and Federal lands.
d. Provide technical assistance for on-farm and other private practices.

*Projects not shown on Figure 12-3

TABLE 12-22. Future projects and programs, Elwha-Dungeness Basins (Cont'd)

Fish and Wildlife

e. Develop lake fertilization techniques.
f. Make wildlife population analysis and timberland management practices studies, develop habitat improvement techniques and an education program on proper game hunting concepts, and begin a program with land owners for game habitat retention and hunter access.
g. Develop fish disease controls and new toxicants.
h. Conduct cross-sectional stream surveys to determine minimum and optimum streamflows for fish.
i. Locate, survey, and mark boundaries of all State-owned second class tidelands in the Basins. Take steps to reserve all such lands for public use except as required for specific circumstances.
j. Perform an inventory of shellfish stocks and recreational use of tidelands.
k. Fertilization of Lake Sutherland.

PROJECTS 1980-2000

Municipal and Industrial Water Supply

28. Enlarge the municipal water supply storage and transmission facilities from Morse Creek.
29. Enlarge the industrial water supply transmission system from Elwha River to Port Angeles.
30. Construct outlet works in Elwha Dam.
31.* Increase capacity and enlarge the small and rural community systems.

Water Quality Control

32. Install additional in-plant industrial waste treatment facilities at Port Angeles.
33.* Expansion of waste treatment and sanitary sewer facilities for municipalities and recreation developments.

Navigation

34. Expand Port Angeles small boat harbor.
35. Expand Elwha River—East small boat harbor.
36. Construct a new small boat harbor—Jamestown.
37. Development of additional water transport-oriented lands in Port Angeles.

Watershed Management

38. Small watershed multiple-purpose project—Morse Creek.
39. Small watershed multiple-purpose project—Port Angeles.
40. Small watershed multiple-purpose project—Dungeness River.
41. Small watershed multiple-purpose project—McDonald Creek.
42. Small watershed multiple-purpose project—Siebert Creek.

Recreation

43. Development of two recreation sites near Lake Aldwell.
44. Development of a salt water recreation site west of Port Angeles.
45. Development of two additional urban recreation sites near Port Angeles.
46. Development of recreational site on Morse Creek.
47. Development of two recreation sites between Siebert and Morse Creeks.
48. Development of recreation site in McDonald Creek drainage.
49. Development of two recreation sites in Lower Dungeness River.

Fish and Wildlife

50. Improve stream and streambed cross-sections, six streams—18 miles.
51. Channel clearance, Dungeness River—8 miles.
52. Fish passage over major barriers on Dungeness River—6 miles.
53. Construct 10 acres of salmon rearing ponds.
54. Construct a new salmon hatchery.

PROGRAMS 1980-2000

Water Quality Control

l. Continue water quality surveillance program.

Flood Control

m. Continue flood plain management program.

Watershed Management

n. Provide technical assistance for on-farm and other private practices.
o. Provide technical assistance and management for State and Federal lands.

Fish and Wildlife

p. Continue fish and wildlife programs.

*Projects not shown on Figure 12-3

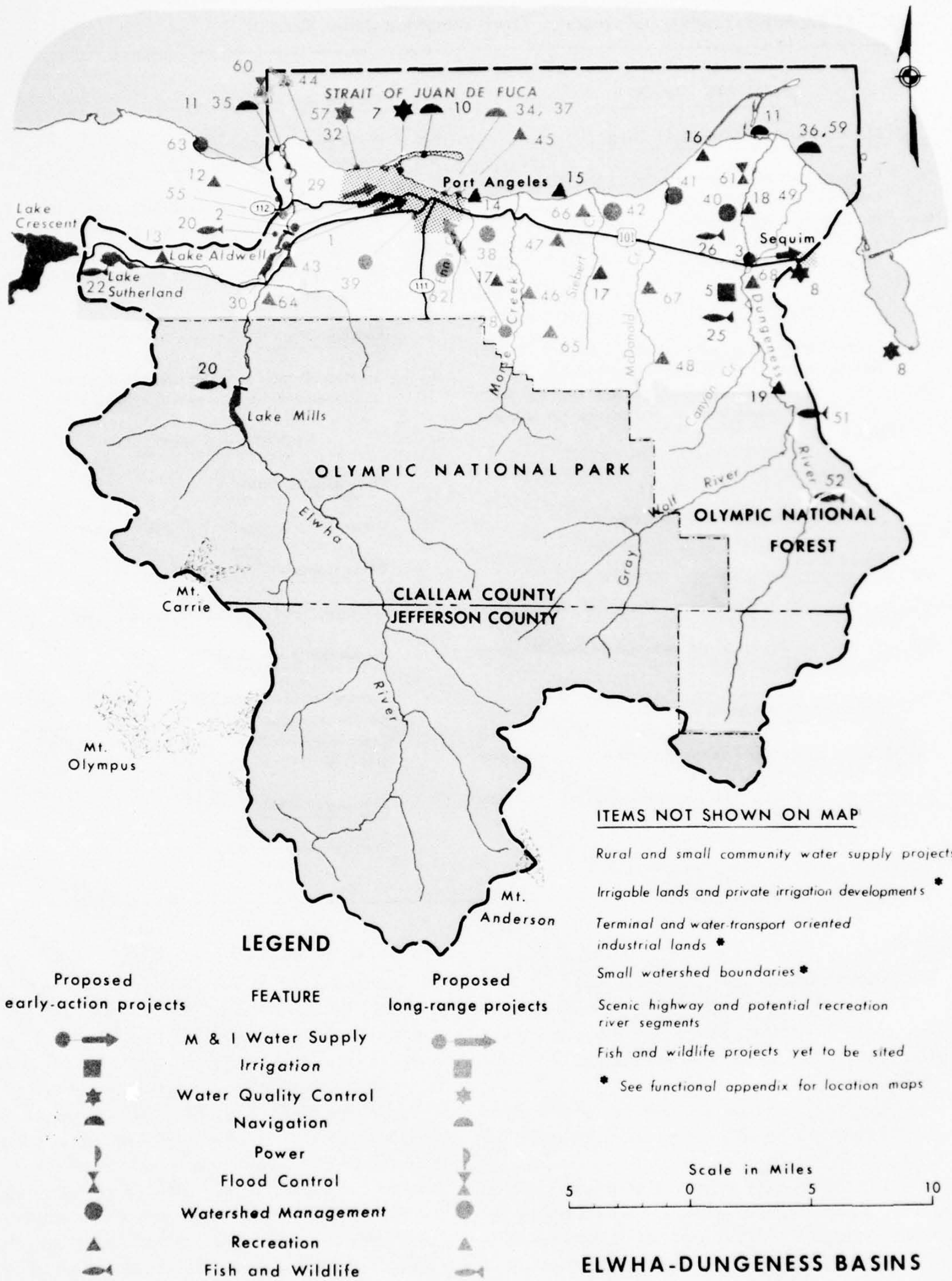


FIGURE 12-3. Comprehensive Plan elements

TABLE 12-22. Future projects and programs, Elwha-Dungeness Basins (Cont'd)

PROJECTS 2000-2020

Municipal and Industrial Water Supply

55. Enlarge the industrial diversion and transmission facilities from Elwha River to Port Angeles.
56.* Increase capacity of transmission and storage facilities at Port Angeles, Sequim and the small rural and community systems.

Water Quality Control

57. Install additional in-plant industrial waste treatment facilities at industries located in Port Angeles.
58.* Expansion of waste treatment and sanitary sewer facilities for municipalities and recreation developments.

Navigation

59. Enlarge small boat harbor—Jamestown.

Flood Control

60. Construct 1.5 miles of levee along right bank Elwha River.
61. Construct 8.0 miles of set back levees along left bank Dungeness River.

Watershed Management

62. Small watershed multiple-purpose project—Ennis Creek.
63. Small watershed multiple-purpose project—Elwha River.

Recreation

64. Development of one recreation site—Elwha River.
65. Development of one recreation site—Morse Creek Watershed.
66. Development of two recreation sites—Siebert Creek Watershed.
67. Development of one recreation site—McDonald Creek.
68. Development of one recreation site—Dungeness River near Sequim.

Fish and Wildlife

69.* Develop 30 acres of salmon rearing facilities.
70.* Obtain land acquisition including habitat areas.

PROGRAMS 2000-2020

Water Quality Control

q. Continue water quality surveillance program.

Flood Control

r. *Continue flood plain management program.*

Watershed Management

s. Provide technical assistance for on-farm and other private practices.
t. Provide technical assistance and management for State and Federal lands.

Fish and Wildlife

u. Continue fish and wildlife programs.

*Projects not shown on Figure 12-3

Accomplishments

Accomplishment of the Comprehensive Plan for the Elwha-Dungeness Basins toward meeting its multiple-purpose needs are summarized in Table 12-23.

The needs can all be met except for flood control and, to a limited extent, the fish streamflow needs.

The flood plain management program would provide some degree of protection by restricting the development on the flood plain. After the year 2000, land use requirement of the expanding population is expected to become critical enough to economically justify construction of the flood control levees. For the Dungeness Basin the levee system, when constructed would provide 25-year protection for approximately 2,200 acres of the 2,900-acre flood plain. One-hundred year protection can be provided by increasing the height and length of the levees.

For the Elwha River Basin flood plain management prior to year 2000 would restrict developments in the flood plain to those compatible with the flood hazards expected. After 1980, incidental flood protection would be obtained with the operation of Lake Aldwell. After year 2000, levees providing 100-year protection would be economically justified.

The minimum streamflows needed for fish as shown in Appendix XI, Fish and Wildlife, cannot be

met due to the lack of adequate storage site locations in the higher reaches, adjudicated water rights for the natural streamflows, and economic justification for a large storage reservoir at the lower elevations. However, the minimum summer streamflow that would be obtained from updating the irrigation facilities would provide substantial benefit for fish in the Dungeness River. The minimum streamflow requirements actually needed for fish production would be determined upon completion of the streambed cross-section measurements.

With no additional upstream storage sites or structural developments in the streams, the upstream watersheds would be maintained in their present natural environment for use by future generations. Construction of by-pass facilities for anadromous fish around Elwha Dam would permit establishment of salmon production in a presently inaccessible area. This would permit returning a large segment of the river to its historic anadromous fish use, denied since construction of Elwha Dam in 1911.

The Basins are noted for their mild climate and unlimited year-round recreational resource and as the focal point for enjoyment of the Olympic National Park. The Basins' port development and three large pulp mills are major contributors to the economy of the area. Construction of water resource facilities and maintenance of the open space as carried in the Plan would assure a balanced environment permitting full development of all aspects of the Basins' economy.

TABLE 12-23. Comprehensive Plan, accomplishments, Elwha-Dungeness Basins

Feature	Units	1970-1980			1980-2000			2000-2020		
		Needs	Accomp.	Residual	Needs	Accomp.	Residual	Needs	Accomp.	Residual
M&I Water Supply	MGD	75.5	75.5	0	144.8	144.8	0	207	207	0
	(1000 Acre-Feet)	83.7	83.7	0	162.8	162.8	0	231	231	0
Irrigation	1000 Acre-Feet	29.1	29.1	0	29.1	29.1	0	29.1	29.1	0
Water Quality Control										
Waste	1000 Population Equivalents	2,681	2,681	0	2,856	2,856	0	2,812	2,812	0
Flow	cfs	0	0	0	0	0	0	0	0	0
Navigation										
Commercial	1000 Short Tons	500	500	0	1,500	1,500	0	3,000	3,000	0
Pleasure Boats	Wet Moorages	1,120	710	410[2]	1,900	1,920	(20)	2,620	2,620	0
Power[1]										
Flood Control	Damage Reduction ($1000)	38	5	33	54	17	37	80	43	37
Watershed Management										
Flood Prevention	1000 Acres[3]	15.9	15.9	0	15.9	15.9	0	15.9	15.9	0
Rehabilitation and Protection of Watersheds	1000 Acres	446.6	446.6	0	446.6	446.6	0	446.6	446.6	0
Water Management										
Agriculture[4]	1000 Acres	9.6	9.6	0	16.1	16.1	0	21.4	21.4	0
Urban[5]	1000 Acres	11	3.7	7.3	11	7.3	3.7	11	11	0
Recreation	1000 User-Days	900	900	0	1,850	1,850	0	3,950	3,950	0
Fish and Wildlife										
Sport										
Fishing	1000 User-Days	145	145	0	394	394	0	887	887	0
Hunting	1000 User-Days	24	24	0	55	55	0	73	73	0
Commercial Fishing	1000 Pounds	922	922	0	1,441	1,441	0	1,643	1,643	0

[1] Power Needs and Accomplishments projected for the Puget Sound Area only.

[2] Residual wet moorage needs assumed to be satisfied by private developments.

[3] The necessary level of management is assumed to be established througout the Basins, otherwise some residual could occur.

[4] Needs and accomplishments are accumulative.

[5] Needs are considered constant, accomplishments are accumulative.

ALTERNATIVE ELEMENTS

Alternative measures to those contained in the Comprehensive Plan for the Elwha-Dungeness Basins which were analyzed and evaluated in satisfying the needs, are discussed in this section along with the reasons for their rejection.

The water supply needs over the 50-year planning period were critical. Although the Elwha and the Dungeness River Basins are included together for report purposes, they are separate hydrologically and to a great extent by their economies. The Elwha River while contained in the Olympic National Park over most of its length is related to an industrial and recreational economy centered around Port Angeles. The Dungeness River, its upper reaches also located in the Olympic National Park, flows through an irrigated agricultural, recreational and retirement home community. The water supply needs had to be evaluated separately.

Water Supply Alternatives—Elwha River Basin

The Elwha River flows through generally undeveloped and sparsely settled areas. The runoff of the river averages 1,095,000 acre-feet with less than 70,000 acre-feet being diverted from the river. Streamflow runoff is shown in Table 12-24.

Outside of some small diversions for agricultural use, the remaining diversion is for the pulp and paper industry in Port Angeles. This trend is expected to continue and the small agricultural diversions would gradually taper off.

The water demands from the Elwha River are shown in Table 12-25.

It is readily apparent that the year 2000 and 2020 needs can never be met completely since their total is greater than the mean flow of the river.

Anadromous fish passage up the Elwha River is limited to the lower 3½ miles due to the location of the Elwha Dam. As can be noted in Table 12-26 the September and October fish flows are greater than the mean flow of the river. Without upstream storage, these could never be met.

TABLE 12-24. Monthly and annual runoff (period: 1931-1960)

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
							Elwha River at McDonald Bridge (269 Sq. Mi.) 1000's Acre-Feet						
Max. (1954)	71	190	182	126	194	91	78	136	145	162	95	59	1,489
Min. (1944)	33	39	74	95	52	44	45	71	82	43	27	24	629
Mean	54	97	123	111	97	77	82	129	142	96	51	36	1,095
							CFS						
Max. (1954)	1,167	2,502	3,035	2,107	3,211	1,517	1,292	2,219	2,418	2,701	1,544	980	
Min. (1944)	534	633	1,194	1,549	883	705	744	1,156	1,370	696	434	406	
Mean	882	1,608	2,044	1,802	1,631	1,245	1,36[illegible]	2,093	2,305	1,576	834	599	

TABLE 12-25. Water requirements, Elwha River (1000 acre-feet)

Present	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
(Water Right)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(108) [1]
Ind.	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	66
Irrig.	--	--	--	--	--	--	--	--	--	--	--	--	--
Fish	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	22 [2]
Total	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	88
1980													
Ind.	13	13	13	13	13	13	13	13	13	13	13	13	156
Fish	55	83	98	98	88	74	78	92	77	61	43	42	889
Total	68	96	111	111	101	87	91	105	90	74	56	55	1,045
2000													
Ind.	19	19	19	19	19	19	19	19	19	19	19	19	228
Fish	55	83	98	98	88	74	78	92	77	61	43	42	889
Total	74	102	117	117	107	93	97	111	96	80	62	61	1,117
2020													
Ind.	25	25	25	25	25	25	25	25	25	25	25	25	300
Fish	55	83	98	98	88	74	78	92	77	61	43	42	889
Total	80	108	123	123	113	99	103	117	102	86	68	67	1,189

[1] Water right of Port Angeles used by industry, but only 5.5 AF/month presently being diverted.

[2] A 30 cfs flow provided by Crown Zellerbach Corporation from Lake Aldwell.

TABLE 12-26. Streamflow for fishery, Elwha River 1980-2020

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
CFS	500	900	1,000	1,000	1,000	700	800	1,200	1,200	700	500	400

Presently there is less than 15 percent of the mean September and October streamflow being diverted. By 1980 about 30 percent would be diverted. Thus, at least 70 percent of the low critical year, mean month historical streamflow would remain in the river for fish production.

Thus, for this study it was assumed that the flows in the river would be adequate for all uses; consumptive and nonconsumptive, through 1980. At that time the minimum flow studies for fish would have been completed and necessary fish flow requirements determined.

After 1980 additional water supplies would be needed. In arriving at the selected alternate, there were three basic alternative elements investigated. Alternative 12-A examined water supply by modifying operation of existing upstream storage; 12-B examined new upstream storage; and 12-C investigated importation of water from outside the Basin. Various combinations of the alternative elements were considered and evaluated.

The water supply solutions are not critical for early action programs of construction. However, the solution arrived at for providing them would have a direct bearing on the development for the remainder of the Basin needs after 1980 and so was investigated in some detail.

12-A—To meet the future water supply needs after 1980, Elwha Dam, which creates the 30,000 acre-foot Lake Aldwell, would be modified. The

reservoir presently has a 3,000 acre-foot active pool which is used solely for power production. Constructing 1,600 cfs outlet works through the left abutment would permit increasing the active pool to 29,500 acre-feet.

Reservoir operation studies for the 30-year period 1931-1960, show that the downstream requirements could be met as follows:

	Year 2000	Year 2020
Immediately below Elwha Dam	100%	99%
Below municipal and industrial diversion	84%	77%

The municipal and industrial diversions are located about 2 miles above the mouth of the river. The cost to construct the outlet works around Elwha Dam is estimated to be $3,000,000.

The addition of a 5,000 acre-foot reservoir on Little River, a tributary stream which flows into the Elwha River just above the upper reaches of Lake Aldwell, would increase the capability of the downstream requirements very little as shown below:

	Year 2000	Year 2020
Immediately below Elwha Dam	100%	99%
Below municipal and industrial diversion	85%	79%

During the 10-year critical period (1936-1945) the year 2020 shortages for industrial and fish uses would average:

	Year 2020	
	AF/Yr.	Percent
With Lake Aldwell only	113,000	12.6
With Lake Aldwell and Little River Res.	102,000	10.0

Modifying the operation of Lake Aldwell would not alter the present or projected recreational and angling use of the lake during the recreation season. It would provide incidental flood control benefits. The power benefits foregone would amount to $130,000 annually.

12-B–Construction of a 365-foot dam at Geyser Basin, located near the headwaters of Lake Mills on Elwha River, could provide nearly all of the future water supply needs. The maximum size of the reservoir would be 100,500 acre-feet with 100,000 acre-foot active capacity.

Reservoir operation studies for the critical year period show that shortages would average 26,000 acre-feet per year, or 3 percent of the annual demand.

The possibility of including power generation facilities at the dam was investigated and found not to be feasible. Hydropower needs are primarily for peaking and there is not adequate storage capacity at the site for its inclusion. Recreation facilities provided at the reservoir would support visitation estimated to be 20,000 visitor-days by 1990.

There would be no specific flood control facilities at the dam, but due to its operation, it would provide a dampening effect upon the high peak storm runoffs which would then be beneficial to fish spawning areas in the lower reaches of the Elwha River.

Construction costs of Geyser Basin dam, reservoir, and recreation facilities, based on 1968 prices are as follows:

Dam and reservoir	$30,000,000
Interest during construction	1,950,000
	$31,950,000
Recreation facilities	$ 100,000
	$32,050,000

12-C–Importation of water from Lyre River, which flows from Lake Crescent, was investigated. The drainage area is small and in order to obtain a minimum diversion of 50 cfs would require 3,300 acre-feet of storage at Lake Crescent. The cost of the facilities to convey the water to Port Angeles would be $5,200,000.

The available streamflow from the Lyre River would not meet all of the water supply needs of the Elwha Basin. However, it could be used in conjunction with either alternative 12-A or 12-B to provide a supplemental water supply. There are no other streams nearby with adequate streamflow for diversion to the Elwha Basin.

The costs and benefits of the alternative plans and combinations based on present-day prices and values, are as follows:

Plan	Investment ($1000)	Annual $1000 Investment	OM&R	Total	Benefits[1]	Net Benefits
12-A	3,000	114	13	227	1,725[2,3]	1,498
12-A Plus Little River Dam	9,200	430	20	450	1,745[2,3]	1,295
12-B	32,050	1,500	31	1,531	1,957[4]	426
12-B Plus Little River Dam	41,050	1,928	38	1,966	1,987[4]	21
12-A Plus 12-C	8,200	383	24	407	1,745[2,3]	1,338
12-B Plus 12-C	37,250	1,742	42	1,784	1,977[4]	193

1 Assume municipal and industrial water supply benefits at $10.00 AF.

2 Includes average annual power generation benefits foregone of 60,000,000 KWH ($130,000).

3 Municipal and industrial–fish enhancement.

4 Municipal and industrial–recreation enhancement.

From the tabulation it can be noted that the water supply features of 12-A have the greatest economic net benefit. Environmentally, 12-A would not detract, but would enhance the aesthetic, natural, wildlife, and other values unique to the basin and was selected.

Water Supply Alternatives–Dungeness River Basin

As related previously, rights to the use of waters of the Dungeness River and its tributaries in the amount of 579.56 cubic feet per second were adjudicated by the State of Washington in 1924. All of the adjudicated rights were for irrigation.

Rights to the use of Dungeness River water, junior in priority to the adjudicated rights, have been issued by the State to the town of Sequim for domestic supply and to the Department of Fisheries for salmon propagation at the Dungeness River salmon hatchery. (The latter right is nonconsumptive). Although these are junior rights, this study has been based on the assumption that an adequate allowance would be made for them from natural streamflow.

With the adjudicated irrigation water right the minimum fish flows cannot be met below the point of diversion even with storage because the combination of the two resource uses exceeds the mean flow of the stream. However, planning proceeded towards developing a means to increase the fish flows to the maximum extent possible consistent with other resource uses.

In developing the Comprehensive Plan there were two basic alternative methods investigated. Under 12-D the needs were examined which could be met without storage, while 12-E examined those needs which could be met with upstream storage.

12-D–Alternative 12-D was selected for the Comprehensive Plan for the Dungeness Basin. The features, costs and benefits for this plan have been discussed under the "Comprehensive Plan." For purposes of economic comparison with 12-E a summary of the investment costs, and annual costs and benefits for 1980 are shown in the following tabulation:

Alternative	Investment ($1000)	Annual $1000 Costs	Benefits Gross	Net
12-D	26,819	6,737	8,477	1,720

12-E—Although all of the desired streamflow requirements cannot be met, even with storage, five alternative sizes of reservoirs ranging from 15,000 to 77,000 acre-feet were investigated to provide varying degrees of streamflow below the dam for irrigation, fish, and flood control. Only one size reservoir is discussed since it meets the greatest amount of the needs and has the greatest net benefit.

Streamflow in the Dungeness River below the irrigation diversion should be increased by construction of a 77,000 acre-foot reservoir at the confluence of the Dungeness and Grey Wolf Rivers. The reservoir would provide:

a. An adequate irrigation water supply for 6,100 acres of lands not now irrigated.

b. Sixty percent of the annual minimum fish flows below the irrigation diversion.

c. Stabilization of the bedload movement in the lower reaches of the river.

d. 100-year flood protection to the 2,900-acre flood plain.

Irrigation water supplies for the new lands would be diverted from the river through the existing open ditch facilities of the nine organized irrigation groups. In conformance with existing practice, water would be pumped from the irrigation ditches and applied to the new lands by sprinkler application.

Minimum streamflow for fish would be maintained above 120 cfs at all times providing adequate transportation water for the anadromous and resident fish as well as additional spawning and rearing areas along the river's edge.

Fish and wildlife mitigation facilities would be required to replace lost production habitat through inundation of upstream spawning areas and big game winter range. The facilities would consist of spawning channels, additional hatchery facilities and habitat development. Mitigation facilities were estimated to cost $5,349,000.

Due to the large fluctuation of the water surface during the recreation season, only minimal mitigation recreational facilities would be provided at the reservoir.

Operation of the reservoir would decrease the peak flows, thus reducing the amount of bedload carried by the river. The reservoir drops to the minimum pool capacity of 1,000 acre-feet during some years. Inclusion of hydro generation facilities would not be a desirable or economical addition.

A summary of the annual costs and benefits of 12-D and 12-E for 1980 are shown in the following tabulation:

	Initial Investment ($1000)	Average Annual ($1000)		
			Benefits	
		Costs	Gross	Net
Alternative 12-D	26,819	6,737	8,477	1,740
Alternative 12-E	56,322	7,949	8,392	443

As can be noted from the tabulation, 12-A has the greatest economic net benefits and would enhance the aesthetic, natural, wildlife, and other environmental values unique to the Basin.

Placing the present and projected irrigation systems in pipe would result in decreased diversion from the Dungeness River. This would permit attaining the flow augmentation and unrestricted passage objectives desired by fish. Flood plain management would control development on the flood plain.

The fish and wildlife and recreational plan developed in 12-D would meet the land acquisition and facility developmental needs including the pleasure boating facility needs. The plan would permit maintaining the unique features of the Dungeness River Basin in their natural environment including the upper reaches of the Dungeness and Grey Wolf Rivers and the Tyler Peak scenic area.

Alternative Flood Protection Facilities

Flood plain management and flood proofing of existing buildings was evaluated as an alternative to major flood protective works for reduction of present and future flood damages. Approximately 40 percent of the estimated $4,000 average annual flood damages or about $1,600, occurs to buildings. These buildings are of wood-frame construction and flood proofing would require structural treatment that is economically unjustified. This alternative has limited application but would not meet the flood control objectives of the Basin.

Reduction in flood damages could be accomplished by levee construction in the early action period but the annual costs of these protective works would exceed tremendously the resulting flood benefits. Flood plain management should be initiated immediately to insure that future developments on the flood plain are controlled.

Alternatives to Morse Creek Watershed Development

The future municipal water supply for Port Angeles can be obtained from Morse Creek watershed development, ground water, or from the Elwha River. It is felt the city can more economically meet its needs through continual development of its Morse Creek watershed along with development of ground water to combat its turbidity problems during the spring months and to meet peaking needs until year 2000. A complete analysis of the ground water availability is unknown at this time and a study should be undertaken in the near future.

The municipal water supply facilities for Port Angeles would have to be enlarged by 1980. The enlarged facilities would then have the capability to deliver peak demands including adequate capacity for fire protection.

Other Alternative Measures

Other alternative measures which were evaluated included possible pump storage sites for power generation, additional water supply and low flow augmentation.

The possibilities of including sills and weirs in the Dungeness River to stop the downstream movement of sand and gravels which smother spawning areas killing eggs and young fry. Use of fish ladders over natural barriers and the possibilities of opening the Olympic National Park for hunting big game.

Development of the land around the town of Agnew into a large industrial area along with a large port development was evaluated. Adequate water supplies are not available along with only fair transportation connections to the central Puget Sound Area. Also, high costs for development of a breakwater needed for the port was a major deterrent.

San Juan Islands

SAN JUAN ISLANDS

DESCRIPTION OF ISLANDS

GENERAL

The San Juan Islands consist of an archipelago of 172 islands which encompasses 176 square miles of land and 1.4 square miles of fresh water. The three main islands, Orcas, San Juan and Lopez contain a large part of the population and industry. There are 473 islands visible at low tide. Areas for the major islands in square miles are: Orcas 58; San Juan 55; Lopez 29; Shaw 8; Blakely 7; Waldron 5; and Decatur 3. The Islands have about 376 miles of salt water shoreline.

Because of their location in the rain shadow of the Olympic Mountains and the Vancouver Island upland, the San Juan Islands receive little precipitation. Annual precipitation ranges between a low of about 18 inches on the southern part of San Juan Island to about 30 inches at higher elevations. Streamflow records are presently not available; however, most streams are characterized by intermittent flow.

Ground supplies are of an unknown quantity as no complete ground water survey has yet been conducted. This is a high priority need throughout the Islands.

Productive ground water aquifers consist of coarse Quaternary sediments. However, the yields of wells in Quaternary aquifers rarely exceed 20 gpm. The largest recorded yield was 50 gpm. Water may occasionally be obtained from more thoroughly consolidated material, however, such quantities rarely exceed 10 gpm.

Streamflow characteristics and other data relating to the hydrology of the Islands are discussed in detail in Appendix III, Hydrology and Natural Environment. The physiographic characteristics of the Islands are described in Appendix V, Water-Related Land Resources.

PRESENT SITUATION

Local Economy

The population of the San Juan Islands in 1950 was 3,200, 1960–2,900, and 1963–2,600. Friday Harbor, the only incorporated city had a population of 784 in 1967. The remaining population is in rural areas, but largely clustered around the unincorporated areas of Waldron, Roche Harbor, Argyle, Richardson, Otis, Decatur, Lopez, Port Stanley, Shaw, Orcas, Deer Harbor, West Sound, East Sound, Rosario, Olga, Doebay, and Thatcher.

Industries that were once active in the past have phased out in the San Juans. Logging and mining and timber operations, while still operative, have declined noticeably in recent years. Agricultural activities have also been declining. The economy of the region is now heavily oriented toward recreation, fishing, and some agriculture.

Total value of farm production in the San Juan Islands is in excess of $500,000 annually. Forestry has declined mainly because of the current lower prices for wood products, fewer markets and a general depletion of local timber resources.

Land Use

The total land area of the San Juan Islands is distributed among the various uses as tabulated in Table 13-1 and shown on Figure 13-1.

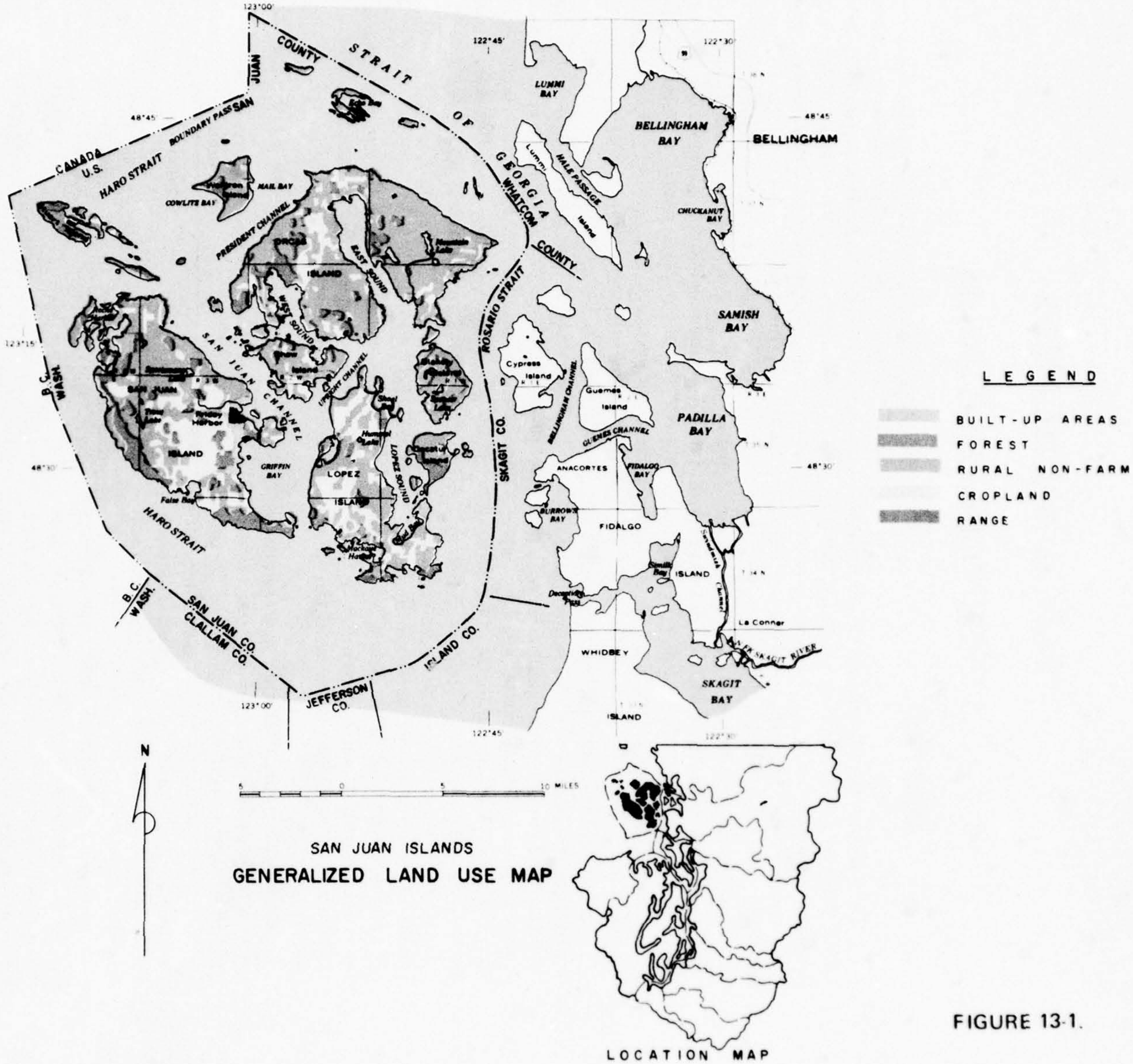
TABLE 13-1. Present land use on the San Juan Islands

Land Use	Area (Acres)	Percent
Cropland	18,600	16.7
Rangeland	9,100	8.1
Forest	71,900	64.5
Rural Non-Farm	9,100	8.2
Urban (built-up)	2,800	2.5
Total	111,500	100.0

Source: Appendix V, Water-Related Land Resources.

The marine environment provides a unique character to the area and has a marked influence upon the local economy. The marine waters support a maritime fishery and many small boating activities.

Forests are the largest user of land followed by cropland and rural non-farm. The rangeland occurs on steep, rocky mountainous slopes. The croplands occupy areas of glacial terraces and lowlands. Crop-



SAN JUAN ISLANDS
GENERALIZED LAND USE MAP

FIGURE 13-1.

lands account for about 17 percent of the land use and occur on the glacial plains and associated lowlands. Forage production (hay, pasture and silage) uses 81 percent of the area classified as cropland area. The remainder of the croplands remained idle.

The intensive land use includes domestic development, commerical, industrial, recreational and transportation uses. The intensive use areas are in the vicinity of Friday Harbor, the several unincorporated areas of the basin and areas adjacent to the many miles of shoreline. The intensive land use is tabulated in acres in Appendix V, Water and Related Land Resources as follows: railroads less than 100; roadways 1,000; airports 500; and urban (built-up) 1,500 for a total of 3,000 acres.

Land ownership is shown in Table 13-2.

TABLE 13-2. Land ownership, San Juan Islands

Ownership	Percent
Private	90
Private Corporate	--
Federal	1
State	8
Local Government	1
Total	100

Source: Appendix V, Water-Related Land Resources.

PROJECTED ECONOMY AND LAND USE

Local Economy

The economy is expected to become increasingly recreation-oriented. The San Juan Islands are the home port for a signficant number of commercial fishing enterprises and may expect some expansion. The timber and wood products industries are expected to continue to decline in activity and importance, while agriculture may continue at approximately its present level. The economic projections for the Islands are tabulated in Table 13-3.

Future Land Use

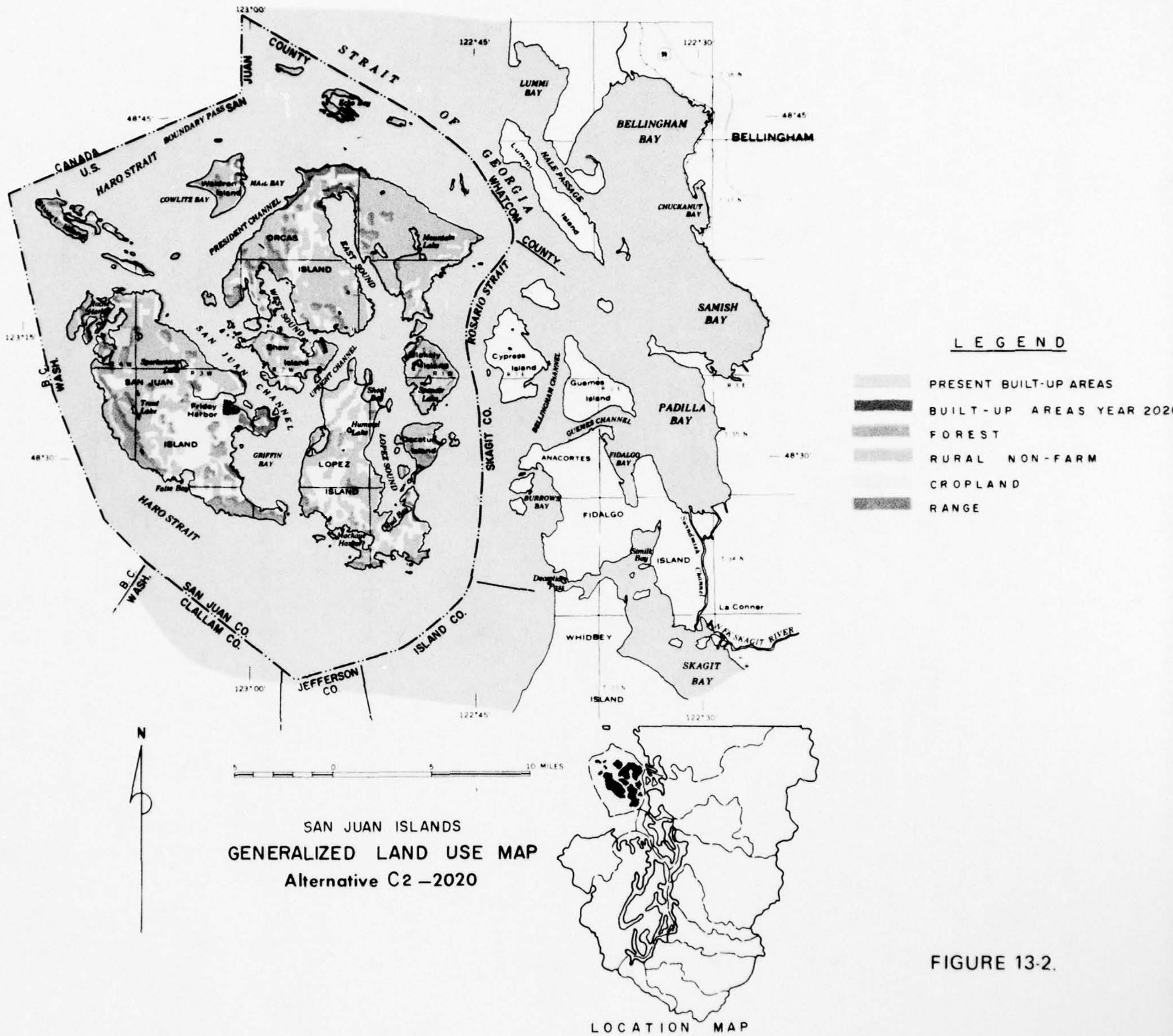
The projected land use of the San Juan Islands for 2020, shown on Figure 13-2 is compared in Table 13-4 with present land use. Transportation from the mainland to the Islands would remain largely by ferry, small boats and air.

Intensive land development is expected to continue along the shorelines of all the Islands and at scattered locations inland. Much of the increased intensive use would probably occur in the vicinity of Friday Harbor and East Sound, the principal communities of the San Juan Islands.

TABLE 13-3. Economic projections, San Juan Islands

		Projections			Average Annual Growth Trend (Percent)			
	1963	1980	2000	2020	1963 To 1980	1980 To 2000	2000 To 2020	1963 To 2020
North Division								
Population (1000's)	1,603.0	2,418.9	3,882.1	6,235.5	2.4	2.4	2.4	2.4
Employment (1000's)	579.1	873.2	1,399.8	2,248.4	2.4	2.4	2.4	2.4
GRP (1,000,000's 1963 $)	5,172.0	10,022.0	24,569.0	62,061.0	3.9	4.6	4.7	4.4
San Juan Islands								
Population (1000's)	2.6	2.8	3.7	5.1	0.5	1.4	1.4	1.2

Source: Appendix IV, Economic Environment, Appendix V, Water-Related Land Resources.



SAN JUAN ISLANDS
GENERALIZED LAND USE MAP
Alternative C2 –2020

FIGURE 13-2.

TABLE 13-4. Present and projected[1] land use, San Juan Islands (acres)[2]

Land Use	Present 1967	1980	2000	2020
Forest	71,900	71,900	71,800	71,800
Range	9,100	9,100	9,100	9,100
Cropland	18,600	18,600	18,600	18,600
Rural non-farm	9,100	8,800	8,700	8,400
Intensive	2,800	3,100	3,300	3,600
Total	111,500	111,500	111,500	111,500
Population 1000	2.6	2.8	3.7	5.1
Density[3]	0.9	0.9	1.1	1.4

Since there is a very limited area available that is well suited for intensive land build-up, particularly vacation and retirement residences, care should be given to site selection.

Availability of water is a matter of concern to some parts of the Islands. The importance of water to the development pattern and economy of the Islands make it a resource to be planned for, conserved and protected.

1 Alternative land use pattern C_2, see Puget Sound Area.

2 Figures rounded to nearest hundred.

3 Persons per intensive land use acre.

Source: Appendix V, Water-Related Land Resources.

WATER AND RELATED LAND RESOURCE NEEDS

MUNICIPAL AND INDUSTRIAL WATER SUPPLY

General

Surface water taken from various streams on the larger islands accounts for about 75 percent of the total municipal and rural-individual water use. These occur principally in the form of springs. Ground water supplies, although presently adequate, offer only limited opportunities for further development beyond 1980.

Because of the increasing influx of the summer population, peak water needs occur simultaneously with a seasonal reduction of surface and ground water supplies. Present municipal and industrial water use for the Basin is shown in Table 13-5.

The San Juan Islands have limited water resources. There are some well-defined perennial stream systems on the larger islands. However, the smaller islands must rely largely upon ground water sources. Some populated areas are experiencing ground water shortages and the problem would become more acute as the projected growth trend continues. Per capita water consumption is expected to decline to the year 1980. This condition would not

TABLE 13-5. Municipal and industrial water use, San Juan Islands, 1965

System	Estimated Population Served	Surface water usage (mgd)			Ground water usage (mgd)		
		Average daily	Maximum monthly	Maximum daily	Average daily	Maximum monthly	Maximum daily
MUNICIPAL USE							
Friday Harbor	1,212	0.33	0.67	0.70	--	--	--
Other Rural Community Systems	1,176	0.11	0.21	0.32	0.15	0.30	0.45
Subtotal	2,388	0.44	0.88	1.02	0.15	0.30	0.45
RURAL-INDIVIDUAL	212	--	--	--	0.01	0.02	0.03
Total	2,600	0.44	0.33	1.02	0.16	0.32	0.48
Summer Population	23,000	--	2.59[1]	3.45	--	0.86[1]	1.15

1 Based on assumed 150 gpod and estimated 75 percent served by surface sources.

Source: Appendix VI, Municipal and Industrial Water Supply.

be due to an inadequate water supply, but rather is reflective on the ability to expand and improve the existing water distribution systems. There is not expected to be any large fresh water using industrial development.

Present and Future Needs

The present supplies of surface and ground water resources are adequate to meet current needs. Immediate studies are needed to determine quality and quantity of the ground water sources.

Future needs are based upon gradual growth together with a rapidly increasing summer population. These needs are projected and summarized in Table 13-6

Per capita water consumption which totaled 185 gpd in 1965, is forecasted to decline to 142 gpd by 1980, and then rise to 158 gpd by 2000, and again reach 185 pgd by 2020. The installation of additional meters and increased water rates to meet system expansion and improvements would partially account for the drop in per capita water use between 1965 and 1980.

IRRIGATION

General

Very little irrigation development has been undertaken in the San Juan Islands. An estimated 100 acres are presently under irrigation and these being in pasture and forage crops. The natural fertility of the soils are low, but they respond well to fertilizers.

The 100 acres presently under irrigation are adequately supplied with water. However, the over all use of water for irrigation purposes is small.

Present and Future Needs

Future need for irrigated land is not projected to increase beyond present levels.

WATER QUALITY CONTROL

General

Surface and ground water quality characteristics are similar. The quality of the waters is

TABLE 13-6. Projected municipal and industrial water needs, San Juan Islands

Year	Use	Total (Avg. Daily M.G.D.)	Total (1000 A.F. annually)	Net Needs[1] (M.G.D.)	Net Needs[1] Acre-Feet (1000)
1965	Municipal	.60	.70		
	Industrial	--	--		
	Rural-Individual	--	--		
	Total	.60	.70	-0-	-0-
1980	Municipal	.60	.70		
	Industrial	--	--		
	Rural-Individual	--	--		
	Total	.60	.70		
2000	Municipal	.80	.90		
	Industrial	--	--		
	Rural-Individual	--	--		
	Total	.80	.90	.20	.20
2020	Municipal	1.20	1.3		
	Industrial	--	--		
	Rural Individual	--	--		
	Total	1.20	1.3	.60	.70

[1] Cumulative total above 1965 use.

Source: Appendix VI, Municipal and Industrial Water Supply.

generally considered good. However, the sanitary quality of these waters has been impaired in some areas as the result of inadequate localized sewage disposal. Water from shallow wells has been reported to be contaminated by this problem.

Approximately 800 PE are being produced daily with an additional 2,800 PE in the summer season. This waste load is discharged to marine waters without treatment. Waste discharges not reaching marine waters are customarily handled by septic tank facilities. The present quantities and sources of waste discharge is shown in Table 13-7

TABLE 13-7. Summary municipal and industrial wastes, San Juan Islands, 1965

Receiving Water	1965 Estimated Population Served	Nonseasonal Untreated Waste PE	Seasonal Untreated Waste PE	Treatment	Nonseasonal Waste Discharge PE	Seasonal Waste Discharge PE
Puget Sound Waters						
Friday Harbor	750	800	--	None	800	--
Food & kindred	--	--	1,000	None	--	1,000
Food & kindred	--	--	1,800	None	--	1,800
Total	750	800	2,800	--	800	2,800
Municipal	--	800	--	--	800	--
Industrial	--	--	2,800	--	--	2,800

Source: Appendix XIII, Water Quality Control.

Present and Future Needs

The rural population relies primarily on septic tanks or other individual means for sewage disposal. This has become a major problem because soil conditions are not well suited to this type of disposal. The paramount need is adequate waste collection and treatment. Small population centers as well as full-time and tourist populations as now developing would aggravate the problem.

The once nearly negligible wastes associated with water craft are now becoming a significant factor in pollution of the marine waters adjacent to the Islands. Table 13-8 shows the projected waste production by municipal, industrial and recreational sources.

To comply with fresh and salt water quality standards, the sewage disposal facilities of many individuals and communities would need to be expanded and updated during the next few years.

The water quality needs are primarily of waste collection and treatment. Proper management of these expected wasteloads is a major need of the future. The existing surveillance program for the marine waters should be expanded. Stations should be established at Lawrence Point, Waldron Island, and Friday Harbor to regularly measure the Water characteristics.

TABLE 13-8. Present and projected raw wasteloadings, San Juan Islands (1000's PE)

Year	Municipal	Industrial	Recreational	Total	Net Needs[1]
1965	1	3	7	11	11
1980	3	3	11	17	17
2000	4	---	20	24	24
2020	6	---	37	43	43

[1] Cumulative raw wasteload requiring treatment above that receiving treatment in 1965.

Source: Appendix XIII, Water Quality Control.

The wasteloads presently being discharged into offshore waters require a sound program for the abatement of future water pollution as well as the restoration of present polluted waters to quality standards. Numerous additional waste treatment facilities would be needed to cope with the projected growth in outdoor recreation, especially pleasure boating on the marine waters.

NAVIGATION

General

Present port facilities scattered throughout the Islands are limited principally to ferry terminals and small boat piers for local traffic. There is no commercial or industrial navigation other than that which is required for local use of the Islands. Most facilities relate directely to small boat usage.

The small boat harbors and related facilities existing on salt water in 1966 provided 390 wet moorages.

Present and Future Needs

Future expansion of terminal facilities will probably be limited to improvement of ferry terminals and boat landings. If the future should indicate a need for additional commercial harbor facilities, there are many natural protected bays and inlets that could be developed.

Some of the Islands are expected to become a recreational center and experience a large increase in boating activity amounting to over a six-fold increase for facilities.

To meet the projected demand for small boat facilities a substantial development of small boat harbors will be necessary. Of the estimated 376 miles of salt water shoreline, approximately 47 miles are considered as having potential for small boat facility development. The projected needs for wet, small boat moorages are indicated in Table 13-9.

TABLE 13-9. Projected pleasure boating needs and waterborne commerce, San Juan Islands

	Small Boat Wet Moorages		Waterborne Commerce[2] (1000's Short Tons)		
Year	Total	Net Needs[1]	Year	Total	Net Needs[2]
1966	2,010	1,620	1963	–	--
1980	2,810	2,420	1980	–	--
2000	4,600	4,210	2000	--	--
2020	7,650	7,260	2020	–	--

[1] Cumulative needs above the 390 moorages available in 1966.

[2] Only minor amount of waterborne commerce occurs in the Islands.

Source: Appendix VIII, Navigation.

POWER

General

As there are no major streams on the Islands, hydropower development is limited to a diversion from Mountain Lake to a small private hydropower plant located at Rosario's Resort on Orcas Island. Orcas Power and Light Company has two fossil-fuel electric generating plants on the Islands. One plant is at Friday Harbor and the other at East Sound. The Bonneville Power Administration also maintains two emergency diesel plants in the San Juan Islands, also at Friday Harbor and East Sound. There are no geothermal power facilities located on the Islands.

Present and Future Needs

The energy needs for the projected population expansion would continue to increase. The Islands' location places them among the potential sites for a potential nuclear fired power plant. There is an abundance of offshore cooling waters and the Islands are close to load centers.

To meet the future power needs of the Puget

Sound Area would require the addition of a number of thermal power plants, primarily nuclear fired plants. These include peaking as well as base load plants. The possibilities of a nuclear fired power plant being located in the San Juan Islands are unknown at this time. Further site location and environmental studies must be conducted in the Puget Sound Area before specific site selections can be made. Further discussion of power needs are presented in the Area portion of this Appendix.

FLOOD CONTROL

The Islands have few major streams and any flood problems are more a matter of ponding due to poor drainage. Accordingly, flooding of this nature will be discussed under watershed management.

WATERSHED MANAGEMENT

General

Watershed management is primarily concerned with treatment measures for flood prevention, watershed protection and rehabilitation, and urban and agricultural water management. Implementation of one measure may be less effective without application of one or more other measures to the same area.

The need in the San Juan Islands is for implementation of integrated programs and projects for reduction of floodwater damage and water management, with rehabilitation and protection of watershed lands regardless of use. The implementation of integrated programs and projects would meet the primary objectives, improve the quality of municipal and industrial water, enhance fish and wildlife habitat and opportunities for recreation, and many elements of the general environment.

Present and Future Needs

The needs for watershed management are complex, and two or more practices and measures may be required on the same area of land. Many measures and treatments become involved in integrated programs and projects. The watershed management needs for the Basin are tabulated in Table 13-10. While the area needing treatment remains nearly the same, the nature and intensity of treatment varies with land capability and changes in use.

The broad needs for improved technology, programs and projects are given in the Area portion of this Appendix.

TABLE 13-10. Total watershed management needs, San Juan Islands

Year	Flood Prevention[1] (acres)	Watershed Protection Rehabilitation (acres)	Water Management (acres)	
			Agriculture	Urban
1980	17,300	111,600	9,900	11,900
2000	17,300	111,600	16,400	11,900
2020	17,300	111,600	21,900	11,900

[1] Includes flooding on main streams but not forested land within the flood plain areas.

Source: Appendix XIV, Watershed Management.

RECREATION

General

As a result of close cooperation and coordination with the State's outdoor recreation planning efforts, information utilized during plan formulation has considered all past and present efforts wherever possible.

Numerous factors such as location and dry climate, together with outstanding recreational resources and opportunities, make the San Juan Islands an ideal recreation area. There are 27 publicly-administered outdoor recreation areas dispersed throughout the Islands. In addition, at least 39 private operators offer facilities for public use. The existing supply of developed lands was inadequate to satisfy the 1960 demands for boating, camping, and picnicking opportunities. This deficiency can be attributed directly to the inability of local public and private sectors to finance needed land acquisition and developments. The tremendous surge in the development of retirement and recreational homes along the shorelines has made public acquisition of water-frontage financially prohibitive.

The outdoor recreation demand in the San Juan Islands was estimated to be more than 1.4 million recreation days during 1960. Of this demand, 72 percent was for water-related activities.

The recreation and tourist industry is likely to become the most important economic activity in the San Juan Islands. The promotion of well-planned developments provide protection of the existing

resources that would satisfy present and future outdoor recreation demands of the people. These efforts would enhance the economic importance of the recreation and tourist industry. As their full potential becomes increasingly evident to the recreating public, the Islands gain additional national recognition.

Present and Future Needs

By the year 2020 there may be more than a six-fold increase in recreation demand. Expressed as recreation user days for the present, 1980, 2000, and 2020, the water-related demand would be as shown in Table 13-11.

TABLE 13-11. Present and projected water-related recreation demand, San Juan Islands (1000's recreation days)

Year	Total	Net Needs[1]
1960	1,000	500
1980	1,900	1,400
2000	3,500	3,000
2020	6,500	6,000

[1] Cumulative needs above 500,000 recreation days satisfied by facilities existing in 1960.

Source: Appendix X, Recreation.

In addition to the indicated needs, scenic routes, waterfront access, harbors of refuge, special interest areas, interpretive facilities, open spaces and associated beaches and trails for activities other than swimming and hiking are needed to satisfy the recreation and environmental requirements of the people.

FISH AND WILDLIFE

General

San Juan Islands are classified as a very limited production area for anadromous fish. This is due to the small size and limited number of spawning streams. Streamflows are primarily dependent upon surface runoff from rainfall which is sparse resulting in greatly reduced summer flows.

The number of salmon produced from the San Juan Islands drainages is too small to make a significant contribution to commercial or sport fisheries of the area, even though salt water fishing is extremely popular throughout the adjacent marine waters. In addition to the anadromous species, sizable quantities of marine fish and shellfish are harvested from the area by both commercial and sport interests.

The black-tailed deer is the only big game animal found on the Islands. Upland game species are limited primarily to the ring-necked pheasant and different species of rabbit.

Present and Future Needs

The prime limiting factor to fish production in the streams of the area is lack of adequate year-round flows. It is doubtful, however, that low flow augmentation would be feasible due to the limited stream areas that would be benefited.

Present and projected user days for fishing and hunting are expressed in Table 13-12.

TABLE 13-12. Fish and wildlife, sport and commercial needs, San Juan Islands

	Unit	1965 Total	1980 Total	1980 Net[1]	2000 Total	2000 Net[1]	2020 Total	2020 Net[1]
Sport Fishing								
Salmon	1000 User-day	79	133	54	244	165	414	335
Game Fish	1000 User-day	10	16	6	25	15	40	30
Marine Fish	1000 User-day	7	9	2	12	5	16	9
Shellfish	1000 User-day	11	15	4	20	9	26	15
Total	1000 User-day	107	173	66	301	194	496	389
Hunting	1000 User-day	50	96	46	155	105	191	141
Commercial Fishing	1000 Pounds	--	--	--	--	--	--	--

[1] Cumulative needs above 1965 activity.

Source: Appendix XI, Fish and Wildlife.

COMPREHENSIVE PLAN

BASIS OF PLANNING

Desires of Local People

At the public hearing held in Anacortes, Washington on October 12, 1964, local interests expressed the need for developing a new source and supply of domestic water, provisions for land stabilization measures, small boat moorages, and recreation lands with facilities interspersed throughout the Islands. Others asked for new sewage disposal systems to prevent land and beach contamination.

Summary of the Islands Needs

The needs for 1980, 2000, and 2020 are summarized in Table 13-13.

TABLE 13-13. Summary of needs, San Juan Islands

Feature	Units	Cumulative Net Needs[1] 1980	2000	2020
M&I Water Supply	mgd	0.0	0.20	0.60
	(1000 Acre-Feet)	0.0	0.20	0.70
Irrigation[2]		--	--	--
Water Quality Control				
Waste Treatment	1000 Pop. Equiv.	17	24	43
Navigation				
Commercial	1000 Short Tons	0	0	0
Pleasure Boats	Wet Moorages	2,420	4,210	7,260
Power[3]		--	--	--
Flood Control		--	--	--
Watershed Management[3]				
Flood Prevention	1000 acres	17.3	17.3	17.3
Watershed Protection & Rehabilitation[4]	1000 acres	111.6	111.6	111.6
Water Management				
Agriculture	1000 acres	9.9	16.4	21.9
Urban	1000 acres	11.9	11.9	11.9
Recreation	1000 User-Days	1,400	3,000	6,000
Fish and Wildlife				
Sport				
Fishing	1000 User-Days	66	194	389
Hunting	1000 User-Days	46	105	141
Commercial	1000 Pounds	0	0	0

[1] See Water and Related Land Resource Needs for derivation of net needs.

[2] Irrigation not expected to exceed present levels.

[3] Power needs have been projected for the Puget Sound Area only.

General Planning

A range of alternative nonstorage and management opportunities were viewed in the San Juan Islands. The water supply alternatives included diversion structures, ground water pumping and treatment, desalinization, inter-island water transfer, further ground water utilization, and improved water yields through various watershed management practices to satisfy water supply needs of municipalities and industry, farming, and water quality preservation and enhancement. Levees, channelization, bank protection and improved land use management practices were considered as possible means of meeting watershed management needs. Opportunities considered for satisfaction of water quality needs were sewage collection and treatment facilities and minimum terms of projected land use pattern C_2 (see Projected Land Use), with the land needs of navigation, power, recreation, and fish and wildlife considered within this context.

There are limited natural storage sites in the Islands which could provide opportunities for meeting water supply needs.

Alternative objectives were considered in developing the Comprehensive Plan. The objectives represented both ends of the spectrum of interests, i.e., economic efficiency and environmental quality as discussed in the Puget Sound Area section of this Appendix. The alternative elements considered in plan formulation are described under Alternative Elements.

The single-purpose Appendices, V through XIV, provided a wide array of solutions. Necessary adjustments were made to these solutions in the formulation of comprehensive plans for the Islands. These adjustments consisted of: ground water would be analyzed prior to 1980 and if found insufficient, diversion from Mountain Lake on Orcas Island could supplement water supplies for that island, Shaw, Lopez and San Juan Islands.

SUMMARY OF PLAN

Early Action, 1970-1980

The early action program emphasizes expansion and analysis of present surface and ground-water supplies and facilities, additional waste treatment and sewers, acquisition of land and construction of recreational facilities, new boat harbors and moorages, and obtaining access to areas for fishing and hunting uses.

Present water supplies are adequate to 1980, although some systems would require new distribution facilities such as meters and larger pipelines.

To comply with the Washington State water quality standards, the city of Friday Harbor would require primary treatment facilities, disinfection facilities and adequate marine discharge throughout the Islands to intercept septic tank effluent and prevent beach and marine-water contamination. Water quality surveillance is an essential element of the water quality program. Stations should be established at Lawrence Point, Waldron Island and Friday Harbor.

There would be four new small boat harbors established throughout the Islands prior to 1980 providing about 1,464 wet moorages. Twelve harbors with 6,300 wet moorages would be constructed between 1980 and 2020.

The recreation plan proposes facilities on 400 acres of lands by 1980. Nearly a third of the early investment would be for purchasing land, principally salt water beach areas and beach access. A coordinated development plan would be established between Federal and state and local governmental bodies to acquire land and develop facilities in an orderly arrangement.

Early action objectives of fish and wildlife would require acquisition of additional land at numerous locations throughout the Islands for public access. These lands would be in addition to those needed by recreation. A controlled rearing impoundment would be developed for salmon production at False Bay in addition to development of a fresh water lake for trout fishing. Fish programs to enhance shellfish production and development of marine water rearing areas are proposed. Game development would include acquisition of additional lands for waterfowl and upland game habitat.

Nuclear power generation was investigated for the Islands. The possibilities of a nuclear power site being located on any of the Islands are indefinite since they are located away from the present and projected main load centers; however, there are many factors to be considered in a site selection which have not been evaluated to date. Therefore, the actual site selection for nuclear power generation has not been included as a part of this plan.

New installations for watershed management, upgrading of existing facilities, and more intense application of recurring and non-recurring land treatment practices, are required. These measures are part of the watershed management program to meet needs for floodwater and sediment damage reduction, water management, and watershed rehabilitation and protection. The cost of this work causes a continuing requirement of public and private funds to protect and develop water and related land resources in the Islands. Watershed management programs that offer technical assistance and financial participation in local land and water related projects and programs would be continued.

Long-Range 1980–2020

To meet future water supply needs for the islands of Orcas, Shaw, San Juan and Lopez, water would be obtained from Mountain Lake on Orcas Island. The western arm of Orcas Island would receive its water from this diversion. However, the community in and around the East Sound area would continue to obtain its water supply from present sources. Water for the other islands would be conveyed by an inter-island pipeline to distribution centers at specified locations throughout the Islands. Individual municipal distribution systems would connect to the pipeline or the distribution centers. The distribution system costs are not included in the plan.

A continuing program of expanding existing and constructing new municipal and industrial waste treatment and sanitary sewer facilities commensurate with a water quality surveillance program would be necessary to meet and maintain Washington State water quality standards.

By the year 2020, an additional twelve harbors with 6,300 wet moorages would be constructed.

Three small watershed projects for floodwater damage reduction, rehabilitation and protection, and water management, should be provided in these Islands prior to 2020. Upgrading of existing facilities and more intensive application of recurring and non-recurring land treatment practices would also be required. Ongoing watershed management programs which provide some degree of technical assistance and financial participation would be continued.

An additional 2,310 acres of land with appropriate facilities would be acquired and developed for recreational use.

To meet the continuing needs of Fish and Wildlife would require acquisition of additional land at numerous locations throughout the Islands for public access. These lands would be in addition to those needed by recreation. Controlled rearing impoundments would be developed for salmon production in addition to development of fresh water lakes for trout fishing. Fish programs to enhance shellfish production, develop marine-water rearing areas, acquire additional lands for waterfowl and upland game habitat are a part of the plan.

Table 13-14 summarizes the San Juan Islands in

TABLE 13-14. Comprehensive Plan, San Juan Islands

Feature	Items	1970-1980 Investment[1] Cost ($1000)	Average Annual Costs ($1000)	Average Annual Benefits Gross ($1000)	Average Annual Benefits Net ($1000)	1980-2000 Investment Costs ($1000)	2000-2020 Investment Costs ($1000)	1970-2020 Investment Costs ($1000)
Management Programs								
Water Quality	Monitoring, Evaluation & Control Programs	340	-	-	-	160	200	700
Watershed Management	Programs	11,897	-	-	-	13,989	13,720	39,606
Fish & Wildlife	Programs	15	-	-	-	0	0	15
Total Programs		$12,252	-	-	-	$14,149	$13,920	$40,321
Non-Storage Projects								
M&I Water Supply	Ground Water Use	670	21	21[2]	0	--	--	670
	Surface Water Use	--	--	--	--	10,200	--	10,200
Water Quality Control	Waste Treatment & Collection Facilities	1,824	44	44[2]	0	2,968	3,600	8,392
Navigation	Small Boat Harbors	(2,951)	(189)	(274)	(85)	(3,625)	(6,100)	(12,676)
Power								
Watershed Management	Protection & Drainage	0	0	0	0	2,736	0	2,736
Recreation	Land Acquisition, access and facilities	15,224	1,112	2,700	1,588	16,200	28,200	59,624
Fish & Wildlife	Production Enhancement Facilities, access, & Acquisition	585	47	103	56	580	676	1,841
Total Non-Storage		$18,303	$1,224	$2,868	$1,644	$32,684	$32,476	$ 83,463
Total Programs and Projects		$30,555	$1,224	$2,997	$1,769	$46,833	$46,396	$123,784

1 Includes cumulative annual program costs for the period for management features and capital costs for projects.

2 Average annual benefits assumed equal to average annual costs.

elements of the Comprehensive Plan, showing the benefits and costs for the early action portion of the Plan, and provides a summary of investment costs by water resource functions for the entire 50-year period ending in 2020. The early action portion of the Plan includes programs amounting to $12,252,000 and projects costing $18,303,000 for a total investment of $30,555,000. Program and project investment costs for the 1980-2000 period amount to $46,833,000 and for the 2000-2020 period, $46,396,000; for a total 50-year investment of $123,784,000.

FEATURES OF THE COMPREHENSIVE PLAN

Municipal and Industrial Water Supply

1970-1980—The present water supply for the Islands is adequate through 1980. Studies of groundwater availability for each major Island should be undertaken during this period and the adequacy of this source to serve the projected populations determined.

1980-2020—If the groundwater sources are inadequate diverting water from Mountain Lake on Orcas Island and conveying it to Shaw, Lopez and San Juan Islands could meet nearly all of the water supply needs for year 2020. Some additional groundwater would have to be developed to meet the peak summer population of year 2020. The surface source from Orcas Island should be used only if future groundwater studies indicate inadequate water supplies.

The water supply for the Islands would be diverted from Mountain Lake for transfer to distribution centers throughout the Islands. The conveyance of water between islands would be via submarine pipelines. Water would be carried under gravity pressure to reservoirs at specified distribution centers. Some pumping would be required as there may not be adequate head at each reservoir to provide the necessary distribution pressures.

The water supply system would be furnished in the following manner: Orcas Island water would be obtained from Mountain Lake via Cascade Lake and subsequently distributed to other islands. A storage reservoir on Orcas Island would supply water for a distribution center at West Sound. The pipeline would continue to the community of Orcas for further distribution. A pipeline across Harney Channel to Shaw Island would be provided. The pipeline would continue with a submarine crossing to Lopez Island and distribution center at the community of Lopez. The San Juan Channel would be crossed by a pipeline between Fishermen Cove and Reef Point. From Reef Point the pipeline would convey water to the major distribution center at Friday Harbor.

Water would be delivered to the individual homes through locally constructed island wide distribution systems diverting from the regulating reservoirs. The Plan for municipal and industrial water supply includes all costs necessary to get water from Mountain Lake to inter-island distribution centers. No distribution system costs or water treatment costs are included in this plan.

A need for the inter-island transfer of municipal and industrial water from a surface source was determined because quantity and quality of ground water supplies have not been adequately surveyed. The assumption is made that in the absence of such information, a plan based upon a known surface water source would be necessary. Existing information indicates that presently utilized supplies of ground water and surface waters are adequate to 1980. The average annual precipitation is projected to yield in excess of 3,000 acre-feet of water into Mountain Lake. Any additional water needs in excess of 3,000 would have to be derived from ground water sources. The enormous influx of summer populations indicate a demand for maximum month needs far in excess of 1980 supplies. It was determined that 94 percent of the net maximum month requirements would have to be supplied from a source such as Mountain Lake. Of this 94 percent, it was assumed that present relative population growth rates would remain constant. Based upon this assumption, water needs were distributed among the Islands with the same percentile allocations as the population estimates. Percentile allocations were determined to be 40 percent for Orcas Island, 46 percent for San Juan Island, 7 percent for Lopez Island, and 1 percent for Shaw Island.

The development of adequate ground water sources will regulate future development on the other islands. Some small watersheds can be developed for small community systems. Small evaporators could also be used for some summer recreation homesite developments if other sources of supply are not available.

The estimate of costs for municipal transmission and inter-island conveyance facilities are shown in the following tabulation:

Development	Construction Period	Investment ($1000)	Annual Cost ($1000) Invest.	OM&R	Total
Transmission system enlargement	Prior to 1980	670	21	--	21
Inter-island conveyance	1980-2000	10,200			

In the areas which have an adequate ground water supply it is assumed they would expand their present facilities to meet nearly all of their future need. However, not all of these areas can meet their total future need from ground water and some would be required to supplement their supplies with the imported surface water.

Irrigation

Irrigation is not included as part of the Comprehensive Plan.

Water Quality Control

Considerable investment would be required to meet the present and future waste collection and treatment requirements.

1970-1980—Waste treatment facilities would be provided at Friday Harbor for primary treatment with disinfection and on adequate marine outfall. The YMCA Camp Orkila would provide for the secondary treatment with complementary facilities. Such facilities are outlined in the Washington State Water Quality Standards and Implementation Plan, December 1967.

With the construction of approximately 3,668 small boat wet moorages, considerable wastes would be generated at the small boat harbors. Approved construction plans would include provision for waste collection and disposal in compliance with water quality standards.

A water quality surveillance program with stations established at Lawrence Point, Waldron Island, and Friday Harbor to effectively monitor the offshore waters is needed. Surveillance at these stations would provide a check-point for the areas where the water quality environment could deteriorate. Installation of these facilities would meet the water quality objectives for the Islands.

The investment costs of the treatment and sewer outfall facilities and projected surveillance program costs are shown in the following tabulation:

Water Quality Control
1970-1980

Feature	Investment Costs ($1000)	Average Annual Costs: Interest & Amortization ($1000)	Average Annual Costs: Operation & Maintenance ($1000)	Average Annual Total ($1000)	Average Annual Benefits[2] ($1000)
Monitoring, Evaluation & Control Program[1]	340	--	--	--	--
Municipal Waste					
Treatment	123	5	1	6	6
Sewers	251	9	3	12	12
Subtotal	$374	$14	$4	$18	$18
Industrial Wastes					
Treatment	225	9	2	11	11
Recreation Wastes	1,225	18	7	15	15
Total Investment	$ 2,164	$31	$13	$44	$44

[1] Cumulative annual program costs for the period.

[2] Benefits are assumed to be at least equal to the cost.

1980-2020–During this period new developments and growth of residential and recreation areas correspondingly would require that new sewer interception systems be installed and treatment facilities enlarged and/or constructed. Summarized below are estimated investment costs for water quality control by sectors for each period.

Water Quality Control
1980-2020

Feature	Investment Costs ($1000) 1980-2000	Investment Costs ($1000) 2000-2020
Monitoring, Evaluation & Control Program	160[1]	200[1]
Municipal		
Treatment	88	66
Sewers	180	134
Subtotal	$268	$200
Industrial		
Treatment	0	0
Recreation	2,700	3,400
Total	$ 3,128	$ 3,800

[1] Cumulative annual program costs for the period.

Navigation

Meeting the salt water small boating needs would require numerous small boat harbors and wet moorages to be constructed throughout the entire Island complex.

1970-1980—The increased demand for small boat moorages would necessitate construction of four new salt water small boat harbors by 1980. These new harbors would provide for 1,480 wet moorages. The additional 940 wet moorages needed by 1980 are assumed to be met by private investment.

The small boat construction sequence is considered only tentative as many factors enter into small boat harbor developments with impacts beyond the capability of the planner to foresee. The construction costs and average annual costs and benefits of the public small boat harbor projects tentatively scheduled for construction by 1980 are tabulated below:

Small Boat Harbor Projects
1970-1980

Location	Wet Moorages	Investment Costs ($1000)	Average Annual[1] Costs ($1000)	Average Annual[1] Benefits ($1000)
San Juan Island (Friday Harbor)	460	(911)	(47.9)	83.9
Orcas Island (Eastsound)	340	(680)	(43.7)	63.3
Blakely Island (Armitage Island)	340	(680)	(43.7)	63.3
Lopez Island (Mackaye Harbor)	340	(680)	(43.7)	63.3
Total	1,480	(2,951)	(179)	(274)

[1] General navigation facilities costs and benefits only based on 50-year economic life amortized at a 4-5/8% interest rate. Total pleasure boat facilities costs and benefits included with Recreation.

1980-2020—Small boat harbor developments would continue with the addition of 1,800 wet moorages by year 2000 and 3,040 wet moorages during the period 2000-2020. These are shown in the following tabulation.

Due to the high construction costs it is expected that these small boat harbor projects would be built by public agencies with Federal assistance. The difference between the projected needs for wet moorage through 2020 and the planned development would be fulfilled within the capability of private enterprise.

The small boat harbor lands and facilities, including Federal and private investment costs and monetary benefits, are carried in the Recreation Plan.

Because of the difficulties now foreseen in obtaining waterfront land in the Islands, local planning is imperative for present development for future expansion. Obtaining the land and water areas and construction of the salt water small boat facilities recommended would meet the navigation objectives for the Islands.

Small Boat Harbor Locations	Tentative Schedule of Development: Wet Moorages 1980-2000	Wet Moorages 2000-2020	Investment Costs ($1000)
Sucia Island (Fossil Bay)	240		
Waldron Island (Cowlitz Bay)	340		
San Juan Island (Roche Harbor)	190		
San Juan Island (False Bay–Phase I)	1,030		
Subtotal	$1,800		$3,625
San Juan Island (False Bay–Phase II)		950	
Stuart Island (Reid Harbor)		240	
Henry Island (Nelson Bay)		340	
San Juan Island (Griffin Bay)		1,180	
Decatur Island (Fauntleroy Point)		340	
Subtotal		$3,050	$6,100

Power

To meet the future power requirements, nuclear generating plants would be required at a number of locations in the Puget Sound Area during the next 50 years. Most of the plants are expected to be located along the salt water shoreline and use offshore water for cooling. The Strait of Juan de Fuca offers an abundance of cold water for cooling. However, before a plant can be located more information is required concerning currents along this area. Circulation of warm water discharge into the adjacent bays may effect either beneficially or adversely the commercial and sport marine fish and shell fisheries. The tolerance of local clam and crab species to the warm water or to rapid water temperature changes is unknown at this time. These aspects must be fully investigated prior to any site selection.

Watershed Management

The development of resources on the Islands will require a watershed management program designed to reduce floodwater damage, rehabilitate and protect watershed areas, and provide water management for a variety of purposes on rural and urban lands.

Many individual measures combine to form the array of practices required to accomplish these purposes. Representative measures are described in Appendix XIV, Watershed Management. While the acreage requiring treatment remains fairly constant by time periods, the intensity of treatment application, and the composition of the combined measures, varies with the inherent capability of the land as well as with the kind and intensity of use. Benefits from proper application of these measures are increased production, protection from watershed deterioration, forest fire protection and enhancement of many environmental qualities.

About 15 miles of beach area on the San Juan Islands are subject to damage from beach erosion and sloughing. This includes the beach erosion on Cattle Point, San Juan Island, and Shaw Island, as well as other islands. Some drifting sand dunes are found near Cattle Point. These would require specific control measures and are discussed further in the Puget Sound Area section.

a third of that would be subject to sloughing. These would require specific control measures and are discussed further in the Puget Sound Area section.

The early action plan consists entirely of land treatment measures to accomplish specific objectives for conservation and development.

There is a continuing investment needed, both public and private, to insure protection of the water and related land within the Islands under projected development. This investment would be made in the form of financial assistance, technical assistance, research, education, and information, and general management of the resource by the public and private agencies. Private investment would be contained in the foregoing programs and in the final accomplishment of the specific project measures.

The project and program measures for each time period are shown in the following tabulation:

Watershed Management
1970-2020

Program	1970-1980 ($1000)	1980-2000 ($1000)	2000-2020 ($1000)
Technical Assistance & Management			
Federal Regular	2,134	2,871	2,871
Federal, Accelerated	0	135	0
Subtotal	$ 2,134	$ 3,006	$ 2,871
Installation of Practices (Non-Federal)			
State and Corporate	990	1,321	1,321
Land Treatment	1,594	2,126	2,126
Watershed Management			
Agricultural	1,828	2,436	1,800
Urban	5,351	5,100	5,602
Subtotal	$ 9,763	$10,983	$10,849
Total	$11,897	$13,989	$13,720

Project		Structural Measures Installation Costs ($1000)	
Orcas-Waldron Islands	0	486	0
San Juan Island	0	1,320	0
Lopez-Blakely-Decatur	0	930	0
Total		$2,736	

The watershed management program, implemented as outlined above, would meet the estimated needs of the San Juan Islands. Because of uncertainties inherent in projections of needs, and in economic projections after 1980, this program should be reexamined periodically.

Recreation

Through the development of suitable areas on existing publically administered lands, approximately half of the picnicking requirements would be satisfied on undeveloped lands, an additional 1400 acres of campground and 600 acres of picnic area would need to be developed to satisfy 2020 demands. These acres do not include the necessary buffer zones on the periphery of developed recreation lands. Approximately one-fourth of the picnicking and camping needs by the year 2020 can be satisfied through the development of suitable areas on existing public lands.

The Islands have significant types and amount of year-round recreation areas. The primary needs are of acquiring lands and public access, and developing recreational facilities for public usage. Some areas need to be retained in their natural state for use by future generations.

The broad recreation goal is to promote well-planned development and protection of the existing resources and to provide an opportunity for the satisfaction of present and future outdoor recreation demands of the population. Based on Federal ownership of land, plans and programs of recreation suppliers, and expected population concentrations as well as outdoor recreation needs, the assumption is made that the Federal agencies would provide 5 percent of the future required water-related opportunities, while the State, county and local agencies, and the private sector would supply 50, 20, and 25 percent, respectively.

The recreation development would be coordinated with the State of Washington Recreation Plan during all stages of development.

To satisfy part of the recreation demand for land and water areas, public acquisition is planned as follows:

Recreation Land and Water Requirements
1960-2020

Activity	Unit	1960 Land	1960 Water	1980 Land	1980 Water	2000 Land	2000 Water	2020 Land	2020 Water
Swimming									
Beach Area	Acres	0	0	0	0	8	1	0	4
Pools	Sq.Ft.	3,000	2,000	7,000	4,000	14,000	7,000	27,000	13,000
Boating, Sailing,									
& Water Skiing	Acres	36	0	81	0	181	0	260	141,000
Camping	Acres	90	--	200	--	400	--	800	--
Picnicking	Acres	50	--	100	--	200	--	300	--
Hiking	Miles	15	--	30	--	70	--	130	--

A similar amount of land acreage in low density use would be required to act as buffer around the developed recreation areas.

1970-1980—During this period an additional 411 acres would be acquired and in some areas, camping, picnicking and other recreation facilities would be developed.

The primary needs of recreation are saltwater access and beach areas. Most of the tidelands are owned by the State and administered by the State Department of Natural Resources. These tidelands have significant value in the satisfaction of recreation demand and the recreation plan assumes that they would be retained in public ownership and access would be provided to them.

A network of scenic roads would be designated and established by the State or county. Scenic-access easements would be established along sections of salt and fresh water shorelines. Archeological sites and historical areas, scattered throughout the Islands, would be retained for public enjoyment.

Investments for recreation facilities other than those discussed previously are tabulated below for the various water-related improvements:

Outdoor Recreation Improvements
1970-1980

Feature	Investment Costs ($1000)	Average Annual Costs: Interest & Amortization	O&M	Total	Benefits
Campgrounds	2,212				
Picnic Areas	336				
Trails	180				
Beaches	0				
Swimming Pools	100				
Boating Facilities	5,619				
Planning and Design	2,112				
Land Acquisition	4,665				
Total	$ 15,224	$ 794	$ 318	$ 1,112	$ 2,700

The developments for 1980 would be capable of meeting the 1980 demands including the unmet demand of 450,000 user-days from 1960.

1980-2020—During this period the additional land and water areas necessary to meet recreational needs would be acquired and developed as needed:

Units	2000 Land	2000 Water	2020 Land	2020 Water
Acres	670		1,310	126,000
Miles	35		115	

The total costs for the recreational lands and facilities on the Islands during the period would be:

Year	Investment Costs($1000)
2000	16,200
2020	28,200
Total	$44,400

A similar amount of land acreage would be required to act as buffer around the developed recreation areas. The recreational developments include interior roads, sanitation facilities, water supply, parking, etc. The recreation areas which should be given firm consideration are shown in Appendix X.

Fish and Wildlife

Due to the lack of streams on the San Juan Islands, there is limited opportunity for additional production of an anadromous fish in this area. Acquiring additional public beach access at both marine and fresh water areas to permit additional angler success, and an expanded program of stocking fish in freshwater lakes would be necessary to retain favorable catch ratios.

1970-1980—Projects and programs needed for the early action fish and wildlife plan are shown in the following tabulation.

Prior to 1980

Projects
(a) Development of 3 saltwater rearing areas.

(b) Development of a freshwater lake.

(c) Acquisition and development of 6 saltwater access areas.

(d) Acquisition for wildlife habitat improvement and hunter access.

(e) Acquisition and development of saltwater access for waterfowl hunting.

(f) Develop marine fish angling piers or jetties to include about 100 acres of fishing access.

(g) Develop marine or fresh-water access areas (boat launch and beach facilities).

Programs

(a) Develop lake fertilization techniques.

(b) Develop cooperative programs with private land owners to maintain habitat and assure hunter access.

(c) Educational program to stress renewable aspect and value of proper utilization of wildlife resources.

The public access areas noted are in addition to the access areas carried in the recreation plan. The costs and benefits for the early action fish and wildlife plan would be:

Fish and Wildlife
Project and Program Costs
1970-1980

Feature	Investment Costs ($1000)	Average Annual Costs: Interest & Amortization ($1000)	Average Annual Costs: O&M ($1000)	Average Annual Costs: Total ($1000)	Average Annual: Benefits Total ($1000)
Project	585	28	19	47	103
Program	15	--	4	4	129
Total	$ 600	$ 28	$ 23	$ 51	$ 232

1980-2020—The early action program places emphasis on obtaining facilities and natural areas to develop an expanded spawning base for fish. After 1980 the program stresses expansion and improvements of the spawning areas and development of new rearing areas for the young fish.

To enhance the hunting and wildlife values in the Islands, an expanded public educational program would be required to stress the proper utilization on new management techniques, and the continuing acquisition of key wildlife habitat and hunting areas.

The investment costs for the period 1980-2020 for the fish and wildlife are:

Fish and Wildlife
Projects and Programs
1980-2020

Feature	Initial Investment
1980-2000	
Projects and programs	$580,000
2000-2020	
Projects and programs	$676,000

Additional local programs for enhancement of fish and wildlife presently being conducted by the Department of Fisheries and the Department of Game would be continued.

COST-BENEFIT SUMMARY

The programs and investment costs by resource function are shown in Tables 13-15 and 13-16 with the costs distributed between Federal, State, local, and private interests. Average annual costs and benefits are shown for the projects recommended for implementation prior to 1980. Interest and amortization costs are based on a 100-year economic life with appropriate allowances made for major replacements. An interest rate of 4-5/8 percent was used in the economic analysis. Benefits for municipal and industrial water supply and water quality improvement were assumed equal to charges.

Investment costs were allocated to the various interests on the basis of available information including the technical appendices.

TABLE 13-15. Program investment costs,[1] San Juan Islands ($1000)

Feature	Private	Government			Total
		Local	State	Federal	
		1970-1980			
Water Quality Control	55	55	170	60	340
Watershed Management	6,107	2,676	980	2,134	11,897
Fish and Wildlife	0	0	15	0	15
Subtotal	$6,162	$2,731	$1,165	$2,194	$12,252
		1980-2000			
Water Quality Control	24	24	76	36	160
Watershed Management	7,125	2,550	1,308	3,006	13,989
Fish and Wildlife	0	0	0	0	0
Subtotal	$7,149	$2,574	$1,384	$3,042	$14,149
		2000-2020			
Water Quality Control	28	28	100	44	200
Watershed Management	6,740	2,801	1,308	2,871	13,720
Fish and Wildlife	0	0	0	0	0
Subtotal	$6,768	$2,829	$1,408	$2,915	$13,920
Total	$20,079	$8,134	$3,957	$8,151	$40,321

[1] Cumulative annual program costs over the period.

TABLE 13-16. Project investment costs[1] and cost-benefit summary, San Juan Islands ($1000)

Feature	Investment Costs					Annual Costs			Annual Benefits	
		Government								
	Private	Local	State	Federal	Total	Interest & Amortization[2]	Operation & Maintenance	Total	Total	Net
					1970-1980					
M&I Water Supply	0	670	0	0	670	21	--	21	21	0
Water Quality Control	225	186	94	1,319	1,824	31	13	44	44	0
Navigation[3]	0	0	0	0	0	0	0	0	0	0
Watershed Mgmt.	0	0	0	0	0	0	0	0	0	0
Recreation	3,806	3,045	7,612	761	15,224	794	318	1,112	2,700	1,588
Fish & Wildlife	0	0	585	0	585	28	23	51	232	181
Subtotal	$ 4,031	$ 3,901	$ 8,291	$ 2,080	$18,303	$874	$354	$1,228	$2,997	$1,769
					1980-2000					
M&I Water Supply	0	10,200	0	0	10,200					
Water Quality Control	0	134	67	2,767	2,968					
Navigation[3]										
Watershed Mgmt.	958	0	0	1,778	2,736					
Recreation	4,050	3,240	8,100	810	16,200					
Fish & Wildlife	0	0	580	0	580					
Subtotal	$ 5,008	$13,574	$ 8,747	$ 5,355	$32,684					
					2000-2020					
M&I Water Supply	0	0	0	0	0					
Water Quality Control	0	100	50	3,450	3,600					
Navigation[3]	0	0	0	0	0					
Watershed Mgmt.	0	0	0	0	0					
Recreation	7,050	5,640	14,100	1,410	28,200					
Fish & Wildlife	0	0	676	0	676					
Subtotal	$ 7,505	$ 5,740	$14,826	$ 4,860	$32,476					
Total	$16,089	$23,215	$31,864	$12,295	$83,463					

1 Capital project costs.

2 Of initial investment and major replacement.

3 Costs and benefits for pleasure boating moorage facilities included with recreation.

SEQUENCE OF DEVELOPMENT

The projects and programs of the Comprehensive Plan are summarized in Table 13-17 by period. The project numbers identify features on Figure 13-3.

TABLE 13-17. Future projects and programs, San Juan Islands

PROJECTS PRIOR TO 1980

Municipal and Industrial Water Supply

1.* Update present municipal and industrial water storage and distribution system for San Juan and Orcas Islands.

Water Quality Control

2. Construct waste treatment and sewerage facilities at Friday Harbor and Camp Orkila.

Navigation

3. Construct small boat harbor at Friday Harbor, San Juan Island.
4. Construct small boat harbor at East Sound, Orcas Island.
5. Construct small boat harbor at Armitage Island.
6. Construct small boat harbor at Mackaye Harbor, Lopez Island.

Recreation

7. Acquire and/or develop one recreation site, San Juan Island.
8. Acquire and/or develop two recreation sites, San Juan Island.
9. Acquire and/or develop three recreation sites, San Juan Island.
10. Acquire and/or develop one recreation site, Lopez Island.
11. Acquire and/or develop three recreation sites, Lopez Island.
12. Acquire and/or develop one recreation site, Decatur Island.
13. Acquire and/or develop one recreation site, Blakely Island.
14. Acquire and/or develop two recreation sites, Shaw Island.
15. Acquire and/or develop one recreation site, Orcas Island.
16. Acquire and/or develop two recreation sites, Orcas Island.
17. Acquire and/or develop one recreation site, Clark Island.
18. Acquire and/or develop one recreation site, Platos Island.
19. Acquire and/or develop one recreation site, Waldron Island.
20. Acquire and/or develop one recreation site, Stuart Island.

Fish and Wildlife

21.* Develop three estuarine rearing ponds.
22.* Develop fresh water lake for trout fishing.
23. Acquisition and development of six salt water access areas.
24.* Acquisition for wildlife habitat improvement and hunting access.
25. Acquisition and development of salt water access for waterfowl hunting and observation.

PROGRAMS PRIOR TO 1980

Water Quality Control

a. Establish and operate water quality surveillance stations at key salt and fresh water locations.

Recreation

b. Provide for the effective recreation use and public access to State-owned tidelands.

Watershed Management

c. Provide technical assistance and management for State and Federal lands.
d. Provide technical assistance for on-farm and other private practices.

Fish and Wildlife

e. Develop lake fertilization techniques.
f. Make wildlife population analysis and timberland management practices studies, develop habitat improvement techniques and an education program on proper game hunting concepts, and begin a program with landowners for game habitat retention and hunter access.
g. Develop fish disease controls and new toxicants.
h. Conduct cross-sectional stream surveys to determine minimum and optimum streamflows for fish.
i. Locate, survey, and mark boundaries of all State-owned second class tidelands in the Islands. Take steps to reserve all such lands for public use except as required for specific circumstances.
j. Perform an inventory of shellfish stocks and recreational use of tidelands.

*Projects not shown on Figure 13-3.

TABLE 13-17. Future projects and programs, San Juan Islands (Cont'd)

PROJECTS 1980-2000

Municipal and Industrial Water Supply

26. Construct municipal and industrial water supply pipeline and storage areas from Mountain Lake on Orcas Island to West Sound of that island and to the other islands of Shaw, Lopez and San Juan.

Water Quality Control

27. Continue construction of waste treatment and sewerage facilities.

Navigation

28. Develop new small boat harbor at Fossil Bay, Sucia Island.
29. Develop new small boat harbor at Cowlitz Bay, Waldron Island.
30. Develop new small boat harbor at Roche Harbor, San Juan Island.
31. Develop new small boat harbor at False Bay, San Juan Island.

Watershed Management

32. Provide small watershed multiple-purpose project for Orcas-Waldron Islands.
33. Provide small watershed multiple-purpose project for San Juan Island.
34. Provide small watershed multiple-purpose project for Lopez-Blakely-Decatur Islands.

Recreation

35. Acquire and/or develop three recreation sites, Lopez Island.
36. Acquire and/or develop one recreation site, Lopez Island.
37. Acquire and/or develop two recreation sites, Lopez Island.
38. Acquire and/or develop two recreation sites, Shaw Island.
39. Acquire and/or develop one recreation site, Shaw Island.
40. Acquire and/or develop one recreation site, Blakely Island.
41. Acquire and/or develop one recreation site, Decatur Island.
42. Acquire and/or develop two recreation sites, Orcas Island.
43. Acquire and/or develop one recreation site, Orcas Island.
44. Acquire and/or develop one recreation site, Waldron Island.
45. Acquire and/or develop one recreation site, Stuart Island.
46. Acquire and/or develop two recreation sites, San Juan Island.
47. Acquire and/or develop one recreation site, San Juan Island.
48. Acquire and/or develop three recreation sites, San Juan Island.

Fish and Wildlife

49. Develop and construct an additional 20 acres of rearing impoundments for salmon.

PROGRAMS 1980-2000

Water Quality Control

k. Continue water quality surveillance program.

Watershed Management

l. Provide technical assistance for on-farm and other private practices.

m. Provide technical assistance and management for State and Federal lands.

Fish and Wildlife

n. Continue fish and wildlife programs.

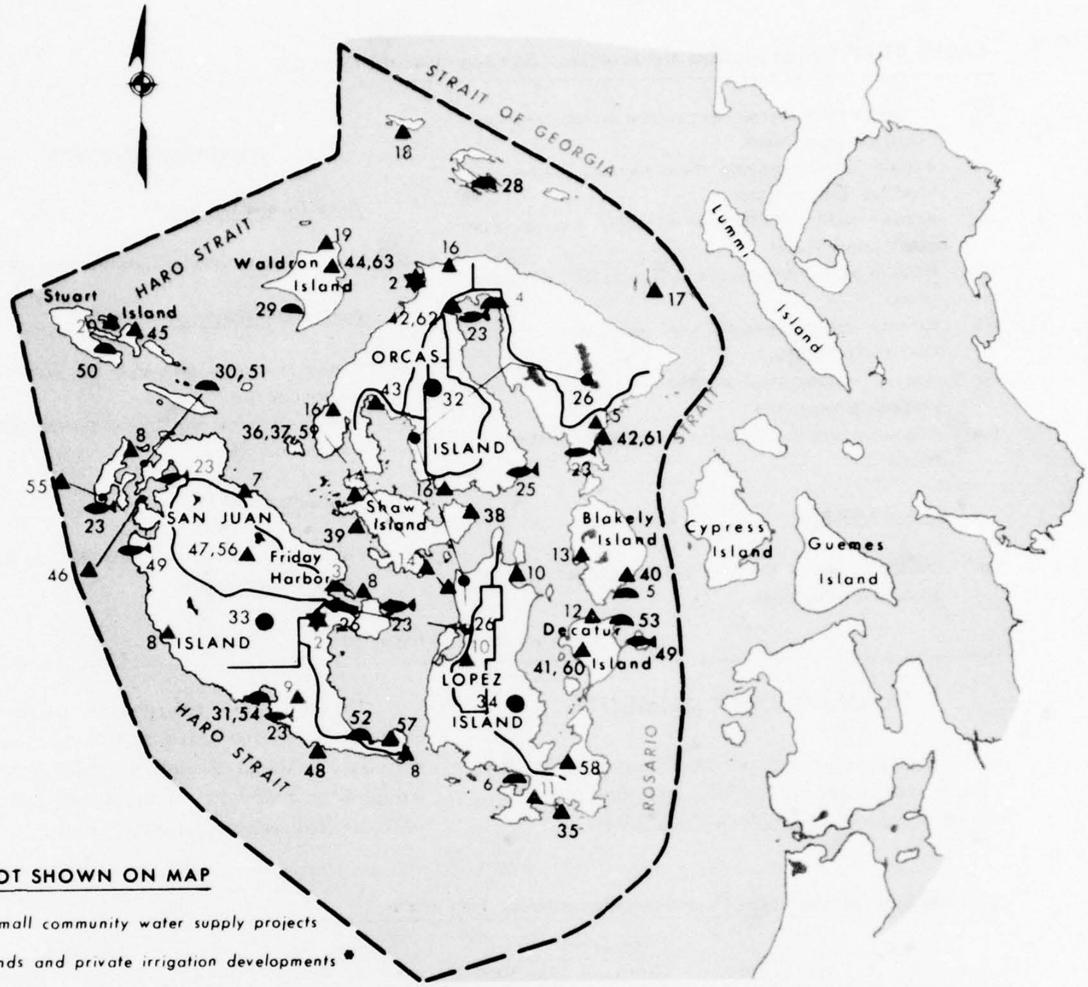
PROJECTS 2000-2020

Navigation

50. Construct small boat harbor at Reid Harbor, Stuart Island.
51. Construct small boat harbor at Nelson Bay, Henry Island.
52. Construct small boat harbor at Griffin Bay, San Juan Island.
53. Construct small boat harbor at Fauntleroy Point, Decatur Island.
54. Construct small boat harbor at False Bay—Stage II, San Juan Island.

Recreation

55. Acquire and/or develop three recreation sites on Henry Island.
56. Acquire and/or develop one recreation site near Sportsman Lake, San Juan Island.



ITEMS NOT SHOWN ON MAP

Rural and small community water supply projects

Irrigable lands and private irrigation developments *

Terminal and water-transport oriented industrial lands *

Small watershed boundaries *

Scenic highway and potential recreation river segments

Fish and wildlife projects yet to be sited

* See functional appendix for location maps

LEGEND

Proposed early-action projects	FEATURE	Proposed long-range projects
	M & I Water Supply	
	Irrigation	
	Water Quality Control	
	Navigation	
	Power	
	Flood Control	
	Watershed Management	
	Recreation	
	Fish and Wildlife	
	Dam & Reservoir	

Scale in Miles

5 0 5 10

SAN JUAN ISLANDS

FIGURE 13-3. Comprehensive Plan elements

TABLE 13-17. Future projects and programs, San Juan Islands (Cont'd)

57. Acquire and/or develop two recreation sites near Low Point, San Juan Island.
58. Acquire and/or develop three recreation sites near Mud Bay, Lopez Island.
59. Acquire and/or develop one recreation site near Flat Point, Lopez Island.
60. Acquire and/or develop one recreation site on Decatur Island.
61. Acquire and/or develop one recreation site near Doebay, Orcas Island.
62. Acquire and/or develop one recreation site near Dolphin, Orcas Island.
63. Acquire and/or develop one recreation site on Waldron Island.

Fish and Wildlife

64.* Provide additional fish and wildlife facilities including access and habitat areas.

PROGRAMS 2000-2020

Water Quality Control

o. Continue water quality surveillance program.

Watershed Management

p. Provide technical assistance for on-farm and other private practices.

q. Provide technical assistance and management for State and Federal lands.

Fish and Wildlife

r. Continuation of fish and wildlife programs including shellfish enhancement.

*Projects not shown on Figure 13-3.

PLAN ACCOMPLISHMENTS

Accomplishments of the Comprehensive Plan toward meeting identified multiple-purpose needs in the Islands are summarized in Table 13-18.

Urban water management needs would be entirely met by the year 2020. In the preceding time periods a residual is shown as intensive land use would be required to achieve a minimum density in order to facilitate project undertaking

TABLE 13-18. Comprehensive Plan accomplishments, San Juan Islands

Feature	Units	1970-1980 Needs	Accomp.	Residual	1980-2000 Needs	Accomp.	Residual	2000-2020 Needs	Accomp.	Residual
M&I Water Supply	1000 acre-feet	0.0	0.0	0	.20	.20	0	.60	.60	0
Irrigation	1000 acre-feet									
Water Quality Control										
Waste	1000 P.E.	17	17	0	24	24	0	43	43	0
Navigation										
Pleasure Boating	Moorages	2,410	1,480	930	4,210	4,210	0	7,260	7,260	0
Power[1]										
Watershed Management										
Flood Prevention,	1000 acres	17.3	17.3	0	17.3	17.3	0	17.3	17.3	0
Water Protection & Rehabilitation[2]	1000 acres	111.6	111.6	0	111.6	111.6	0	111.6	111.6	0
Water Management[3]										
Agriculture	1000 acres	9.9	9.9	0	16.4	16.4	0	21.9	21.9	0
Urban	1000 acres	11.9	4.0	7.9	11.9	7.8	4.1	11.9	11.9	0
Recreation	1000 user-days	1,400[2]	1,400	0	3,000	3,000	0	6,000	6,000	0
Fish & Wildlife										
Sport										
Fishing	1000 user-days	66	66	0	194	194	0	389	389	0
Hunting	1000 user-days	46	46	0	105	105	0	141	141	0
Commercial										
(fish)	1000 pounds	--	--	--	--	--	--	--	--	--

[1] Power needs and accomplishments projected for the Puget Sound Area only.

[2] The necessary level of management is assumed to be estalbished throughout the Islands, otherwise some residual damage could occur.

[3] Needs and accomplishments are cumulative.

ALTERNATIVE ELEMENTS

Alternative measures to those elements contained in the Comprehensive Plan and reasons for not adopting these alternatives are discussed in this section.

Alternative to Water Supply Features of Comprehensive Plan

The possibility of providing a water supply to the Islands through desalinization was investigated.

The conversion of sea water to a potable supply for municipal and industrial use has received considerable attention in recent years. Attention has been focused on the economies which can be realized by constructing nuclear power plants in conjunction with a desalinization plant. The desalinization plant can utilize steam generated by the power plant's nuclear reactor during off-peak hours which otherwise would be wasted in a straight power plant operation and a single organization can care for the operation and maintenance of both plants.

Water costs for desalinization are constantly decreasing with improved technology, but this solution to water supply problems is economically feasible only in a few extreme situations where the nearest potable supply is a considerable distance away. The U. S. Atomic Energy Commission predicts costs as low as 19 cents per 1,000 gallons for the integrated nuclear power desalting plants by 1980, but costs of this order would be realized only in extremely large plants producing 500 to 800 million gallons per day. The San Juan Islands year 2020 peak requirements are for 17.7 mgd. Water supply pipeline conveyance costs for the Islands, from the desalinization plants, would be in addition to the above stated costs.

It appears unlikely that an economical desalinization break-through would occur within the next few years which could assist the San Juan Islands in meeting their water supply needs. If such a break-through does occur, then this plan should be re-evaluated.

GLOSSARY

Acre-Foot (ac. ft.)—A unit commonly used for measuring the volume of water or sediment; equal to the quantity of water required to cover one acre to a depth of one foot and equal to 43,560 cubic feet or 325,851 gallons.

Alluvium—Soil material, such as sand, silt, or clay, that has been deposited by water.

Anadromous Fish—Species that are hatched in fresh water, mature in salt water, and return to fresh water to spawn.

Angler-day—A day or any part of a day spent fishing by an individual.

Aquifer—A rock formation, bed, or zone containing water that is available to wells. An aquifer may be referred to as a water-bearing formation or water-bearing bed.

Arable Lands—Lands which are delineated by classification procedure as suitable for irrigation development.

Artesian Water—Ground water under sufficient pressure to rise above the level at which the water-bearing bed is reached in a well. The pressure in such an aquifer commonly is called artesian pressure, and the rock containing artesian water is an artesian aquifer.

Base Flow—See Base Runoff.

Base Runoff—Sustained or fair weather runoff. In most streams, base runoff is composed largely of ground water effluent. The term base flow is often used in the same sense as base runoff. However, the distinction is the same as that between streamflow and runoff. When the concept in the terms base flow and base runoff is that of the natural flow in a stream, base runoff is the logical term.

Basin—A geographic area drained by a single major stream. For the purposes of this study the Puget Sound and Adjacent Waters Area has been subdivided into the following nine basins and the Whidbey-Camano and San Juan Islands.

1. Nooksack-Sumas
2. Skagit-Samish
3. Stillaguamish
4. Snohomish
5. Cedar-Green
6. Puyallup
7. Nisqually-Deschutes
8. West Sound
9. Elwha-Dungeness

BOD (Biochemical Oxygen Demand)—The quantity of oxygen utilized in biochemical oxidation of organic matter in a specified time and at a specified temperature. It is determined entirely by the availability of the material as a biological food and by the amount of oxygen utilized by the micro-organisms during oxidation. Usually expressed in terms of BOD_5, it is the quantity of oxygen utilized in a five-day period at 20°C.

Bottom Land—Lowland formed by alluvial deposits along a river or stream.

Capacity Factor (Electric Power)—The ratio of the average load on the generating plant for the period of time considered to the capacity rating of the plant.

Capital Expenditures—Outlays for plant and equipment which are normally charged to fixed asset accounts.

cfs (Cubic Foot per Second)—A unit of discharge for measurement of flowing liquid equal to a flow of one cubic foot per second past a given section. Also called second-foot.

Channel Storage—The volume of water at a given time in the channel or over the flood plain of the streams in a drainage basin or river reach. Channel storage is sometimes significant during the progress of a flood event.

Chlorination—The application of chlorine to water, sewage, or industrial wastes generally for the purpose of disinfection, but frequently for accomplishing other biological or chemical results.

COD (Chemical Oxygen Demand)—The quantity of oxygen utilized in the chemical oxidation of organic matter. It is a measure of the amount of such matter present.

Coliform Bacteria—A species of genus escherichia bacteria, normal inhabitant of the intestine of man and all vertebrates.

Construction Cost—The total cost of construction, including real estate, engineering, design, administration and supervision.

Consumptive Use—The quantity of water discharged to the atmosphere or incorporated in the products in the process of vegetative growth, food processing, industrial processes, or other use. Hence, the amount of water no longer directly available.

Consumptive Use Irrigation—All withdrawals are considered to be consumptive unless the full amount of the withdrawal is returned to the source.

Demand (Fish and Wildlife)—The number of hunter-days, angler-days, non-hunting or fishing use, or commercial harvest that are expected at a given date.

Demand—A need or desire. (Differs from the usual economic definition of demand under which a need is not necessarily reflected in a demand).

Depletion, Streamflow—The amount of water that flows into a valley, or onto a particular land area, minus the water that flows out of the valley or off from the particular land area.

Design Load—The maximum number of recreationists expected to use an area at any one time on an average weekend day during the peak month of annual visitation for which facilities and land or water would be provided.

Discharge—In its simplest concept, discharge means outflow; therefore, the use of this term is not restricted as to course or location and it can be used to describe the flow of water from a pipe or a drainage basin.

Discharge, Average—The arithmetic average of the annual discharges for all complete water years of record whether or not they are consecutive. The term "average" is generally reserved for average of record and "mean" is used for average of shorter periods; namely daily mean discharge.

Diversion—The taking of water from a stream or other body of water into a canal, pipe or other conduit.

DO (Dissolved Oxygen)—The oxygen dissolved in water or other liquid, usually expressed in milligrams per liter or percent of saturation.

Domestic Coastwise Receipts and Shipments—Domestic waterborne commerce receiving a carriage outside of the Puget Sound Area.

Domestic Internal Receipts and Shipments—Domestic waterborne commerce between ports or landings wherein the entire movement takes place within Puget Sound Area.

Drainage Area—The drainage area of a stream, measured in a horizontal plane, which is enclosed by a drainage divide.

Drainage Basin—A part of the surface of the earth that is occupied by a drainage system, which consists of a surface stream or a body of impounded surface water together with all tributary surface streams and bodies of impounded surface water.

Drainage Divide—The line of highest elevations which separates adjoining drainage basins.

Economic Base Study—A study which evaluates the economic structure of the region to provide economic projections necessary for the appraisal of future water resource needs.

Effective Precipitation—That part of the precipitation falling on a crop area that is effective in meeting the consumptive use requirements of the crop.

Effluent—Municipal or industrial waste water which is partially or completely treated or in its natural state, flowing from a process basin, or treatment plant.

Environment—The total of all external factors that affect an animal. Not to be confused with Habitat, which refers to the place where an animal is found.

Erosion, Bank—Destruction of land areas located adjacent to a stream from the erosive action of high stream discharges.

Escapement—Number of anadromous fish that return from the ocean to fresh-water streams and spawn.

Estuary—Semi-enclosed body of water which has a free connection with the open sea and within which ocean water is measurably diluted with fresh water derived from land drainage.

Eutrophication—The process of over-fertilization of a body of water by nutrients which produce more organic matter than the self-purification processes can overcome.

Exceedence Frequency—Percent of values that exceed a specified magnitude.

Farm Delivery Requirement—The amount of water in acre-feet per acre required to serve a cropped area from a canal or pipe turnout. It is the crop irrigation requirement plus farm waste and deep percolation.

Fingerling—Young fish which are self-subsistent, but not yet mature.

Firm Power—Power intended to have assured availability to the customer to meet all or any agreed upon portion of his load requirements.

Fish Farm—A controlled natural rearing impoundment or relatively small pond for fish.

Flood—Any relatively high streamflow or an overflow or inundation that comes from a river or other body of water and causes or threatens damage.

Flood Peak—The highest value of the stage or discharge attained by a flood; thus, peak stage or peak discharge. Flood crest has nearly the same meaning but, since it connotes the top of the flood wave, it is properly used only in referring to stage.

Flood Plain—A strip of relatively smooth land bordering a stream that has been or is subject to flooding. It is called a "living" flood plain if it is overflowed in times of high water, but a "fossil" flood plain if it is beyond the reach of the highest flood.

Flood, Probable Maximum—The largest flood for which there is any reasonable expectancy in the geographical region involved.

Flood Stage—The stage at which overflow of the natural banks of a stream begins to cause damage in the reach in which the stage is observed.

Flood, Standard Project—A hypothetical flood that might result from the most severe combination of meteorological and hydrological conditions that are reasonably characteristic of the geographical region involved. The SPF is an important consideration for design of flood control structures.

Floodway—The channel of a river or stream and those parts of the flood plains adjoining the channel which carry and discharge the floodwater or floodflow of any river or stream.

Food Fish—In Washington, those species of fish which may be harvested and sold as a commercial venture.

Foreign Imports and Exports—Waterborne commerce between the Puget Sound Area and foreign ports including the Canal Zone.

Freeboard—The vertical distance between a design maximum water level and the top of a structure. This space is utilized for safety.

Gaging Station—A particular site on a stream, canal, lake or reservoir where systematic observations of gage height or discharge are obtained.

Game Fish—In Washington, those designated species of fish which may be taken by sporting means only.

Gigawatt (gw)—One million kilowatts.

gpcd—Gallons per capita per day.

gpd—Gallons per day.

Ground Water—Water in the ground that is in the zone of saturation from which wells, springs and ground water runoff are supplied.

Habitat—Area which supplies food, water, shelter, and space necessary for a particular animal's existence.

Harbors of Refuge—A temporary haven for small craft in distress or seeking shelter from approaching storms; also a safe place of rest and replenishment for transient boats.

Hardness—A characteristic of water; chiefly due to the existence therein of the carbonates and sulfates and occasionally nitrates and chlorides of calcium, iron, and magnesium; which causes "curdling" of.

Hunter-day—A day or any part of a day spent hunting by an individual.

Hydrogen Ion Concentration (pH)—The weight of hydrogen ions in grams per liter of solution. Commonly expressed as the pH value that represents the logarithm of the reciprocal of the hydrogen ion concentration.

Hydrologic Cycle—A term denoting the circulation of water from the sea, through the atmosphere, to the land; and, thence, with many delays, back to the sea by overland and subterranean routes, and in part by way of the atmosphere without reaching the sea.

Industrial Water—The industrial category includes those major water-using industries whose size is related to a significantly larger population than that of the local area and whose water needs are normally supplied through a municipal distribution system. For the purposes of this analysis, these industries are the following:

Pulp and paper
Other major forest products
Food processing
Petroleum processing
Primary metals
Thermal and nuclear power

Infiltration—The flow of the fluid into a substance through pores or small openings. It connotes flow into a substance in contradistinction to the word percolation, which connotes flow through a porous substance.

Interception (Hydrology)—The process of storing rain or snow on leaves and branches or other objects which eventually evaporates back to the air.

Intraport Receipts and Shipments—Which include waterborne commerce between the arms or channels of a port, as between the inner and outer harbor of the Port of Seattle, and local traffic movement of freight and passengers within the confines of a single arm or channel of a port.

Irrigated Land—Land receiving water by controlled artificial means for agricultural purposes from surface or subsurface sources.

Irrigation Conveyance Loss and Waste—The loss of water in transit from a reservoir, point of diversion, or ground water pump (if not on farm) to the point of use, whether in natural channels or in artificial ones, such as canals, ditches, and laterals.

Irrigation Depletion—The amount of diverted water consumptively used, beneficially and nonbeneficially, in serving a cropped area. It is the gross diversion minus return flow.

Irrigation Requirement, Crop—The amount of irrigation water in acre-feet per acre required by the crop; it is the difference between crop consumptive use requirement and effective precipitation.

JTU (Jackson Turbidity Units)—The JTU is a measurement of the turbidity, or lack of transparency, of water. It is measured by lighting a candle under a cylindrical transparent glass tube and then pouring a sample of water into the tube until an observer looking from the top of the tube cannot see the image of the candle flame. The number of JTU's varies inversely with the height of the sample (e.g., a sample which measures 2.3 cm has a turbidity of 1,000 JTU's whereas a sample measuring 72.9 cm has a turbidity of 25 JTU's).

Kilowatt (kw)—The electric unit of power which equals 1,000 watts or 1.341 horsepower.

Kilowatt-Hour (kwh)—The basic unit of electric energy. It equals one kilowatt of power applied for one hour.

Lagoon—A relatively shallow basin, built by excavation of the ground and diking, for the purpose of treating wastes by storage under conditions that favor natural biological treatment and accompanying bacterial reduction.

Land Use—Primary occupier of a tract of land grouped into classes with similar characteristics, i.e., cropland, rangeland, forest land, or other.

Load Factor—The ratio of the average load over a designated period to the peak-load occurring in that period.

Man-day—Synonymous with angler-day and/or hunter-day.

Major Replacement Costs—Costs of replacement of rehabilitation of major structural or equipment items within the project life.

Marina—A marine development having moorages. Other facilities may be available, including repair facilities, bait, tackle and general supply services. Restaurants and hotels or motels are often part of a modern marina complex.

Marine Fish—All fish species that spend their entire life in salt water. Includes bottom fish such as flounder and sole.

Megawatt (mw)—One thousand kilowatts.

Megawatt-Hour (mwh)—One thousand kilowatt-hours.

mgd—Millions of gallons per day.

mg/l—Milligrams per liter.

Moorage Facility—One or more piers, wharves, floats, or permanently anchored buoys to which boats can be secured and left in the water for storage purposes; or land or deck storage areas used with hoists or inclined railways.

MPN (Most Probable Number)—In the testing of bacterial density by the dilution method, that number of organisms per unit volume which, in accordance with statistical theory, would be more likely than any other possible number to yield the observed test result or which would yield the observed test result with the greatest frequency. Expressed as density of organisms per 100 ml.

Municipal Water—The municipal category includes not only urban domestic water use but also those other civic, commercial, and small industrial uses which are typically supplied through a municipal distribution system and the magnitude of which is related to local population.

Nonconsumptive—Nonconsumptive uses related to surface water only, are where no water is diverted from the confines of the surface water source area or channel, where the waters pass over, under, around or through an on-stream project, or when being diverted (effectively) at the upstream edge of a project and being returned (effectively) to the channel at the downstream edge of a project. It is considered nonconsumptive water use when water diverted from a surface water source is returned to the same source at any location upstream from the point of diversion. Transportation losses, evaporation, and seepage are not considered consumptive.

Nonstructural Measures—Measures for managing, utilizing, or controlling water and related lands without structural development to achieve the desired objective. Such measures include flood plain zoning, flood warning systems, legal restraints, and preservation, as well as the more common land management measures.

Operation and Maintenance Costs—Average annual costs of project operation and normal maintenance.

Opportunities—Potential developments or potential utilization capable of being realized.

Outdoor Recreation—Leisure time activities which utilize an outdoor setting.

Outdoor Recreation Activity—A specific lesire time action or pursuit in an outdoor environment.

Outdoor Recreation Area—A land and/or water area where outdoor recreation is recognized as the dominant or one of the major resource management purposes.

Outdoor Recreation Site—A tract of land developed for specific recreation activities.

Outdoor Recreation Unit—A facility or group of complementary facilities designated to accommodate a family or other small group.

Outfall—A sewer, drain, or conduit from which sewage, industrial wastes, or drainage is discharged.

Peak Load—The maximum load in a stated period of time. Usually it is the maximum integrated load over an interval of one hour which occurs during the year, month, week, or day. It is used interchangeably with peak demand.

pH—See Hydrogen Ion Concentration. The neutral value of pH is 7.0. Higher values indicate an alkaline solution and lower values indicate an acid solution.

Population Equivalent (PE)—The average daily amount of BOD_5 exerted by the organic waste from one person. A value of 0.17 pounds of BOD_5 is normally equated to one PE.

Potential Pleasure Boat Mooring Harbors—Harbors under this category are sites now developed for pleasure boat moorages or having physical characteristics suitable for this use.

Potential Terminal Facilities—Waterfront open space that is suitable for waterborne commerce terminals and generally includes water area out to the pier head line or about 40 feet depth below MLLW.

Potential Water Transport-Oriented Industries—Open space areas suitable for water transport-oriented industry including waterfront land not required for terminal facilities and inland to a maximum of about 5 miles from possible deep water transport terminal.

Potentially Irrigable Land—Land having soil, topography, drainage, and climatic conditions suitable for irrigation.

ppm—Parts per million.

Primary Waste Treatment—The removal of settleable, suspended, and floatable solids from waste water by the application of mechanical and/or gravitational forces. In primary treatment, unit processes such as sedimentation, flotation, screening, centrifugal action, vacuum filtration, dissolved air flotation, and others designed to remove settleable, suspended, and floating solids have been used. Generally, a reduction in dissolved or colloidal solids has been obtained in primary treatment, but this effect is incidental and not the planned purpose of primary treatment.

Public and Private Marine Facilities—Public facilities refer to marine facilities operated by public agencies such as State, counties, cities, and ports for use by the general public. Private facilities refer to marine facilities operated for profit by private ownership. They are available for general public use.

Puget Sound Area—The twelve counties in northwestern Washington bordering Puget Sound and Adjacent Waters. These consist of Whatcom, San Juan Island, Skagit, Snohomish, King, Pierce, Kitsap, Thurston, Mason, Jefferson, and Clallam Counties. Only Puget Sound and adjacent saltwaters were examined with reference to marine facilities and boating demand. Lake Washington was included as an extension of Puget Sound.

Range—Land area used by an animal. Most common reference is to the seasonal ranges (winter, summer, fall/spring) used by big game animals.

Recurrence Interval—The average number of years within which a given event will be equaled or exceeded.

Registered Boat—An undocumented craft propelled by an engine of more than 10 horsepower, used on navigable waters of the United States and registered by the United States Coast Guard, as required by the Federal Boating Act of 1958.

Rehabilitation—Chemical treatment of a body of water to remove undesirable fish populations, followed by restocking with desired species. Term is also used to mean renovation of land.

Resident Fish—Species that spend their entire life cycle in a fresh-water environment.

Reservoir—A pond, lake or basin, either natural or artificial, for the storage, regulation, and control of water.

Return Flow (Irrigation)—Irrigation water applied to an area which is not consumed in evaporation or transpiration and returns to a surface stream or ground water aquifer.

River Reach—Any defined length of a river.

Runoff—That part of the precipitation that appears in surface streams. It is the same as streamflow unaffected by artificial diversions, storage or other works of man in or on the stream channels.

Runoff, Average Annual—Average of water year runoff in inches or acre-feet for the total period of record.

Salinity—The relative concentration of dissolved salts in seawater and is determined by various methods when compared to the international standard of Eau de Mer Normale. Usually expressed in parts per thousand = 0/00.

Salmonid—Refers to cold-water fishes of the family salmonidae. Represented by the salmon, trout, whitefish, and chars (such as Dolly Varden and brook).

Scrap Fish—Pertains to marine species. Includes all mixed fish purchased for reduction or animal feed which dealers have not separated as to species. Mostly dogfish, hake, and tomcod.

Secondary Treatment—The removal of dissolved and colloidal materials that, in their natural state as found in waste water, are not amendable to separation through the application of primary treatment. Secondary treatment will generally reduce the BOD_5 of sewage by 85 percent.

Sediment—(1) Any material carried in suspension by water which will ultimately settle to the bottom after the water loses velocity. (2) Fine waterborne matter deposited or accumulated in beds.

Service Areas—An area described for planning purposes whose boundaries would include the future population or industrial activities which could logically and functionally obtain water supply and waste disposal services from a central or integrated system or where the problems are so interrelated that the planning should be done on an integrated basis.

Sludge—The accumulated settled solids deposited from sewage or industrial wastes, raw or treated.

Storage—Water naturally or artificially impounded in surface or underground reservoirs.

Storage Capacity, Active (Usable)—The volume normally available for release from a reservoir below the stage of the maximum controllable level (total capacity less inactive and dead capacity).

Storage Capacity, Dead—The volume of a reservoir below the sill or invert of the lowest outlet.

Storage Capacity, Exclusive Flood Control—The space in reservoirs reserved for the sole purpose of regulating flood inflows to abate flood damage.

Storage Capacity, Surcharge—The volume of water in a reservoir between the designed maximum water surface elevation and normal pool elevation for either a gated or ungated spillway.

Storage Capacity, Total—The total volume of a reservoir exclusive of surcharge.

Stream—A general term for a body of flowing water. In hydrology, the term is generally applied to the water flowing in a natural channel as distinct from a canal. More generally, as in the term stream gaging, it is applied to the water flowing in any channel, natural or artificial.

Streamflow—The discharge that occurs in a natural channel. Although the term discharge can be applied to the flow of a canal, the word streamflow uniquely describes the discharge in a surface stream.

SWL—An abbreviation for sulfite waste liquor, a by-product of sulfite-type pulp and paper mills.

Terminal Facilities—The area of piers, wharves, open and covered storage areas used for waterborne commercial cargo and passenger service together with mooring areas for such vessels.

Tertiary (Advanced) Treatment—Selective application of biological, physical, and chemical separation process to effect removal or organic and inorganic substances, primarily phosphorous and nitrogen, that resist conventional treatment practices.

User-days—Of general recreation, angling and/or hunting; expressed demand.

Water-Related Activities—Those activities that are water-based or enhanced by water.

Watershed—A term to signify drainage basin or catchment area.

Water Table—The upper surface of a zone of saturation. No water table exists where that surface is formed by an impermeable body.

Water Transport-Oriented Industries—Waterfront and other lands being used by industries that require or gain a significant advantage by nearness to water transport facilities. Industries of this type are:

Transportation Equipment Manufacture
Primary Metal Manufacture
Chemicals and Allied Products Manufacture
Petroleum Refining and Related Industries
Paper and Allied Products Manufacture
Wholesalers With Stocks, Distributors
Lumber and Wood Products Manufacture
Stone, Clay and Glass Products Manufacture
Warehousing and Storage

Water Yield—Runoff, including ground water outflow that appears in the stream, plus ground water outflow that leaves the basin underground. Water yield is the precipitation minus the evapo-transpiration.

Zero Damage Flow—The maximum flow a stream can carry without causing overbank flow and damages.

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